ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XLVII. No. 20.

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TWO REMARKABLE RAILWAY RUNS were made within the past two weeks. One of them was made on May 8 by an eastbound through express train on the Pennsylvania R. R. The train left Harrisburg, Pa., 58 mins. late, on its way to New York; to make up this time it covered the distance of 126 miles to Morristown, N. J., in 125 mins., at an average speed of 60 miles per hour maintained for over two hours. The train was made up of engine No. 1,968 hauling one combination car, one day coach and four Pullmans. The other run, while a better performance in itself, was made by a light special train for the particular purpose of making a long-distance high-speed run. The train consisted of a new engine of the Marshall type, hauling one day coach and two private cars. The route was from Buffalo, N. Y., to Cleveland, O. over the tracks of the New York Central & Hudson River R. R. and the Lake Shore & Michigan Southern Ry. The distance of 183 miles between Buffalo and Cleveland was covered in 180 minutes; in other words, an average speed of over 60 miles per hour was maintained for three consecutive hours, while some portions of the route were doubtless covered at very much higher rates of speed. It is said the trip was made with the object of testing the practicability of running a daily 18-hour train between New York and Chicago; the present "standard" time of through passenger trains between these cities is 28 hours.

AMERICAN LOCOMOTIVES FOR RUSSIAN RAILways are recommended by the Russian Government Railways Advisory Board. The 24 locomotives lately built for the Central Russian Railway, at the Charkoff Works, in Russia, have been condemned as practically useless. The contract provided for a speed limit of 50 miles per hour; but the maximum speed obtained was 18 miles. As a consequence the board referred to is reported as having decided to purchase all locomotives abroad, as was formerly the practice. The Baldwin Locomotive Works alone have shipped 419 locomotives to that country, including all types.

THE SHALLOW RAILWAY SUBWAY, following the surface level of the street as nearly as possible, is commended in a recent report to the London Board of Trade, presented by Col. H. A. Yorke, R. E., chief inspecting officer of railways. He reports in full upon the construction and operation of the Metropolitan subway in Paris, and points out the economy of construction, greater ease of access, greater opportunity for escape in case of accident and purer air. Of course, Colonel Yorke is comparing this shallow railway with the deep tunnels built and proposed for London railways.

TWO NEW GRAIN ELEVATORS, for storing Manitoba wheat, are being erected at Montreal and Fort William by the Steel Storage & Elevator Construction Co., of Buffalo, N. Y. The contract price for the Montreal elevator is stated at $606,000. This Montreal elevator will be founded on piles; have a concrete foundation extending 23½ ft. above the ground-level to the base of the storage bins; and the 82 bins are of the cylindrical type, with varying capacities. The total storage capacity will be nearly one million bushels; and the shipping capacity 80,000 bushels per hour. The same company is to build a similar elevator at Fort Williams for the Canadian Pacific Railway Co.

AN ELECTRIC COAL BREAKER is being constructed at the Auchincloss Colliery of the Lackawanna R. R. Co., near Nanticoke, Pa. In this mine electric power is being installed for light, hoisting from a 1,720-ft. shaft, for operating ventilating fans, for transportation and for picking or cleaning the coal. Electricity is generated at the mine. The 25 mechanical pickers have a capacity of 60 tons each per day, and 25 men will replace the 200 boys formerly employed. The new installation is designed by Mr. George F. Hill, of New York.

CANADIAN ELECTRICAL POWER AND LIGHT statistics are included in the last annual summary issued by Mr. George Johnson, Dominion Statistician. There were in 1901 in Canada 306 lighting companies, with 12,800 arc lights and 815,676 incandescent lamps. Railway charters are now before the legislature adding 1,046 miles to the existing rural electric mileage in the Province of Ontario alone. In the Province of Quebec some 50 miles of electric railway will probably be built during the coming summer.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Union Pacific R. R., on May 7, near Topeka, Kan. An extra freight train ran into a regular freight at a crossing. In the resulting wreck two men were killed and about half a dozen injured.

A PECULIAR SEQUENCE OF ACCIDENTS brought about the death of over twenty persons, and injured several hundred others, on May 12, near Pittsburg, Pa. The original cause of the calamity was a slight wreck of some cars which were being shifted in the yards of the Pittsburg, Cincinnati, Chicago & St. Louis Ry. of the Pennsylvania Lines West of Pittsburg. Two tank cars filled with refined oil and one filled with naphtha were among the wrecked cars, and one of the oil cars was started leaking. The escaping oil ignited at a broken switch light, and the tank exploded, pouring the burning oil over the neighboring tracks. This oil made a very hot fire, and the heat caused the second car of oil to burst in half an hour after the first. Meanwhile the adjacent hillsides were thickly covered with people who had come to watch the fire, and when, an hour later, the naphtha car exploded, the oil was thrown in a burning shower right in the midst of the massed crowds of spectators. A wild panic followed. Men, women and children to the number of several hundred were burned more or less, and probably a score of them lay dead within a few minutes. It is thought that of the injured a number will die. A quantity of the oil flowed into a small creek, Cork's Run, and floated down the stream. Two miles below, near the Pittsburg city limits, a natural gas main ran along in a ditch near the creek, and a leak in the main was ignited by the blazing oil. An explosion resulted that wrecked a whole group of nearby houses, killed several persons outright and injured fully a score of others.

A VOLCANIC ERUPTION on May 8 completely destroyed the city of St. Pierre, on the French island of Martinique, in the Windward Group of the West Indies, killing all the inhabitants of the city and the neighborhood, and destroying all the shipping in the port. For some time past unusual activity of the volcano of Mont Pelée, near St. Pierre, had been observed. Large quantities of smoke and volcanic dust were ejected during the week previous to the disaster, and on May 6 it was reported that a flow of lava from the crater had destroyed a factory only two miles from St. Pierre. Cable communication with Martinique had been interrupted on May 4, and it was thought that this was to be charged to volcanic activity. On the morning of May 8, it appears, a rain of molten lava from the crater of Mont Pelée deluged the entire neighborhood, set the whole city of St. Pierre in flames, and killed all the people in the city, a population of over 25,000. Of the ships in the harbor, only one escaped, the British steamer "Roddam," and she was badly damaged and a number of the people on board killed. Disastrous volcanic activity is also reported from the island of St. Vincent, in the same group, about 100 miles south of Martinque, and more than a thousand lives are reported lost there.

A FIRE DEPARTMENT WATER TOWER raised by a Pelton water wheel has been built by the fire department of San Francisco, Cal. The idea has been developed by Mr. Henry Gorter, machinist of the fire department. The Pelton wheel is mounted on the lower truck and is supplied with a 2¾-in. stream from fire engines.

BIDS FOR A MUNICIPAL HEATING FRANCHISE are wanted at Racine, Wis., until June 16, 1902, as stated in our advertising columns. Mr. Henry J. Schroff is City Clerk.

SLOW SAND FILTRATION for the water supply of Providence, R. I., seems to be assured at last, after some ten years' agitation for purer water. A joint special committee of the city council has recommended the improvement named and the city council has passed an ordinance directing the Commissioner of Public Works to contract for a plant, to be built on city land at the Pettaconsett pumping station in accordance with the plans of the city engineer, provided the cost does not exceed $225,000. The city engineer, it is said, has plans completed and estimates that the sum just named will be sufficient to build a plant having a daily capacity of 18,000,000 to 20,000,000 gallons. The beds will not be covered.

TURBIDITY AND COLOR STANDARDS have been elaborated for the hydrographic division of the U. S. Geological Survey by Messrs. Allen Hazen, M. Am. Soc. C. E., of 220 Broadway, New York city, and Geo. C. Whipple, Assoc. M. Am. Soc. C. E. The standards will be used by the survey in connection with its measurements of stream flow and it is hoped that they will be adopted generally by engineers and water-works superintendents throughout the country. The turbidity standard is based on the immersion of a bright platinum wire in water containing a fixed value of silica. The color standard is based on a platinum-cobalt solution. In the case of turbidity, a combined platinum wire gage and scale is employed for field use, but since the standard color tubes cannot be carried over the country disks of colored glass have been provided for standards. Full details regarding these standards, with directions for their use in both field and laboratory, have been included in Circular No. 3, Division of Hydrography, U. S. Geological Survey, by Mr. F. H. Newell, Hydrographer, Washington, D. C.

WROUGHT IRON GAS MAINS rather than cast iron are strongly urged by Mr. Godfrey L. Cabot, of Boston, Mass., in an article published in "The American Gas Light Journal" for May 12, 1902. He recommends that the wrought-iron pipe beneath paved streets or bad ground "be swathed in a double thickness of cloth soaked in coal-tar pitch," thereby saving sufficient leakage and repairs to pay the additional cost. In unpaved streets of good clay soil special protection will not generally be necessary. For fittings, malleable iron is recommended, so far as possible; otherwise, insist on a good quality of cast iron. Mr. Cabot concludes, after an extensive investigation in many cities in this country and abroad, that leakage from cast iron, in the cities studied, was in every case "incomparably greater than in our own wrought-iron mains, which have a total length of from 60 to 70 miles, and handle from 9,000,000 to 10,000,000 cu. ft. per day." Even after making allowance for more favorable conditions under which the (Boston?) mains are laid, Mr. Cabot believes that "the evidence still remains very greatly in favor of wrought iron." While wrought iron, like cast, is subject to electrolysis, it has the possible advantage of fewer current breaks at joints.

AN ADAMS EXPRESS CO. STEAM WAGON has been built by the American Ordnance Co., of Bridgeport, Conn., after the designs of Mr. Arthur Herschmann. The water-tube boiler has about 70 sq. ft. of heating surface and is located on the front platform, just in front of the front axle. This boiler is tested to 250 lbs. and is to carry 175 lbs. working pressure; full steam can be made from cold water in about 30 minutes. Provision is made to protect all pipes from freezing. The front wheels are 4 ft. diameter, the rear wheels 4 ft. 6 ins. The frame is made of I-beams, rigidly braced at corners, and a distinguishing feature of the truck is a design whereby the springs are no longer rigidly clipped to the axles, but have slide-pieces at their middle which work in a guide-frame depending from the I-beam frame. The engine is a two-cylinder horizontal compound. The tanks carry 85 gallons of water, and the fuel used is hard coal; the load capacity of the truck is two tons.

GOLD DREDGING has become an important industry in California and large amounts of gold are being reclaimed from the river beds. The Feather River, near Oroville, is a point of great activity. Here the river debouches on a plain at the foot of a canyon and an area of about 10,000 acres has been covered with the earth and "slickens" brought down by the stream along whose upper courses much of the gold gained in the primitive days of California's mining industry was won. A considerable impetus has been given to the industry by the development of long-distance electric transmission lines in this part of California. These furnish current by which the electric motors which drive the dredging machinery are operated.

TELEPHONE WIRES ARE BEING PUT UNDERground between St. Paul and Minneapolis by the Northwestern Telephone Co. For a portion of the distance, in St. Paul, there will be provision for 4,000 wires and for the remainder, for 2,400. In St. Paul the company has about 2½ miles of tunnel, deep down in the soft sandstone, on the sides of which cables are hung.

THE NEW BREAKWATER AT PORT COLBORNE, ONTARIO; WELLAND CANAL ENTRANCE.

The Canadian government is now making extensive improvements at Port Colborne, Ont., the point where the Welland Canal leaves Lake Erie. These improvements consist: First, of an outer breakwater to create an artificial harbor, and the deepening of a portion of this harbor adjacent to the breakwater. Second, the building of extensive piers for elevator sites, the deepening of the harbor adjacent to these piers, affording safe access to the same for the large lake vessels; the deepening of the outer and inner entrances to the Welland Canal, the latter entrance being more generally known as the Welland canal basin; the demolition and rebuilding of the present retaining walls of this basin; also the deepening of the summit level of the Welland Canal, north of the Port Colborne locks. Third, the lowering of the miter sill of the larger lock 3 ft. below its present level.

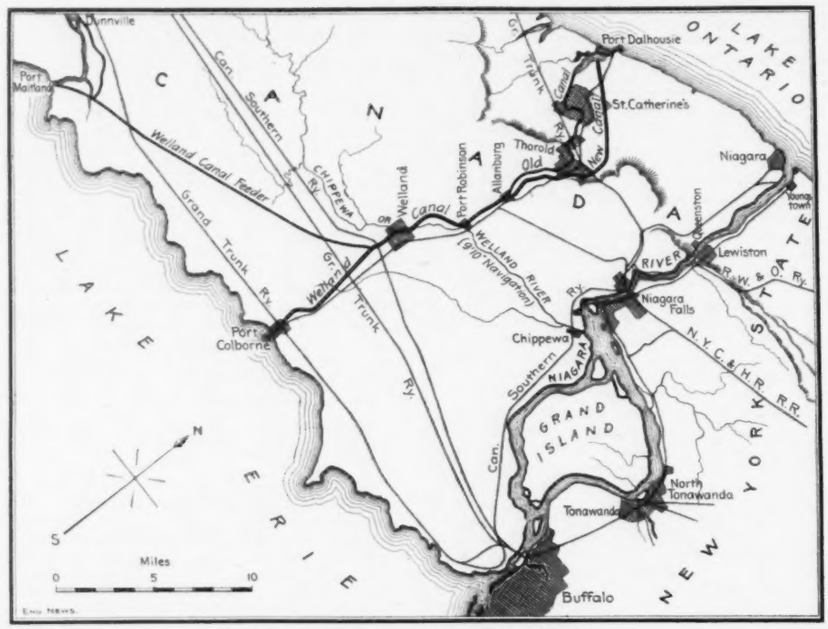


FIG. 1. MAP OF THE WELLAND CANAL.

The work enumerated under the first head is being executed under the direction of the Department of Public Works of Canada, of which Mr. Eugene D. Lafleur is the Acting Chief Engineer. The local engineer in charge is Mr. Louis Coste. The work named under the second head is being done by the Department of Railways and Canals, of which Mr. Collingwood Schreiber, Deputy Minister, is the Chief Engineer. Mr. F. D. H. Lawlor, M. Am. Soc. C. E., is the local engineer in charge, he having succeeded Mr. J. S. Weller, now superintending engineer of the Welland Canal, at St. Catherines, Ont., in place of Mr. W. G. Thompson, M. Am. Soc. C. E., M. Inst. C. E., resigned. It may be stated here that Mr. Thompson designed the plans for the Port Colborne Entrance Improvements.

The contractors for the works enumerated under heads 1 and 2 above are Messrs. Hogan & Macdonell. Mr. Arthur Stephen, C. E., is the engineer for the contractors. The lowering of the miter sill of the Port Colborne lock is expected to be done by the regular repair forces of the Welland Canal.

THE WELLAND CANAL—HISTORICAL.

As these improvements are intended to develop an increased traffic over the Canadian canals, a few words concerning the history of the Welland Canal may be of interest. The present line of the canal, as seen by Fig. 1, connects Lake Erie, at Port Colborne, with Lake Ontario, at Port Dalhousie, its length being 26¾ miles. The difference in level between the two lakes, about 327 ft., is overcome by 25 lift locks. The elevation of Lake Erie above sea level is 573 ft., while that of Lake Ontario is 246 ft.

The project for connecting Lakes Erie and Ontario by means of a canal was broached over 80 years ago. The construction of the original canal was commenced in 1825 by an incorporated company. Owing to the difficulties encountered at the summit, then as now called the Deep Cut, a change was made from the original plan of using the Welland River as a feeder, and the Grand River was substituted as a source of supply. A dam was built at what is now the town of Dunnville, and a channel was cut from there to Port Robinson, 27 miles, at an elevation about 15½ ft. higher than the summit level first contemplated. A short branch connected this feeder with Lake Erie at Port Maitland, at which place vessels were locked in and out. Subsequently the route of the canal was changed southward, to nearly the same line that it now occupies. The new route was opened to the passage of vessels on May 20, 1833.

The channel of this first canal was narrow; the locks were 100 ft. long and 22 ft. wide, and chiefly built of wood. The canal company suffering continued financial embarrassment, the control of the canal finally passed to the Canadian government in 1841, the "Board of Works" taking charge of the same.

In September, 1841, an appropriation was ed for the enlargement of the canal. Th locks were to be of stone, the entrance lo Port Colborne and Port Dalhousie to be 2 long, 45 ft. wide, and to have 9 ft. of water sills. The other locks to be 120 ft. long, wide, with 8½ ft. of water on the sills. W the enlargement was started in 1842. In 18 was decided to change the dimensions of t terior locks to 150 ft. long between gates, 2 wide, with 9 ft. of water on the sills. The of the entrance locks was also changed to 11 on the sills at the lowest known stages o respective lakes. The bottom width of the was generally 26 ft.

The work of enlargement included the d ing and widening of the Welland feeder. Th larged canal by the feeder, between Port land and Port Dalhousie, was opened in 1845 part of the canal between Port Colborne an junction was laid dry to permit its excava and was not completed until 1850. The dep water in the canal available for navigation then 10 ft.

In 1871, it was decided to enlarge the canal available depth of 12 ft. of water being fixed. In 1874 and 1875, public opinion demanded a gre depth, which was assented to by the governm and the depth changed to 14 ft. of water on the ter sills of the locks. In enlarging the canal, the old location, between Port Colborne and Allanburg 15 miles, was maintained, the canal prism being merely widened and deepened. Between Allanburg and Port Dalhousie, 11¾ miles, however, an entirely new location was selected for the enlargement, being to the eastward and northward of the old canal. Fig. 1 shows the location of the two canals. The locks on the enlarged canal are 45 ft. wide at the level of the lower reach, and 270 ft. in length between hollow quoins. The canal was opened in 1883, for vessels drawing 12 ft. of water, and in May, 1887, for vessels drawing 14 ft. Fig. 2 is a profile of the Welland Canal, showing location of levels and locks, and needs no further description. The total cost of construction of the Welland Canal to June 30, 1900, was $23,771,635.76.

TRAFFIC ON THE CANAL.

The total quantity of freight passed through the Welland Canal, and the tolls received during the seasons of 1898 and 1899, were as follows:

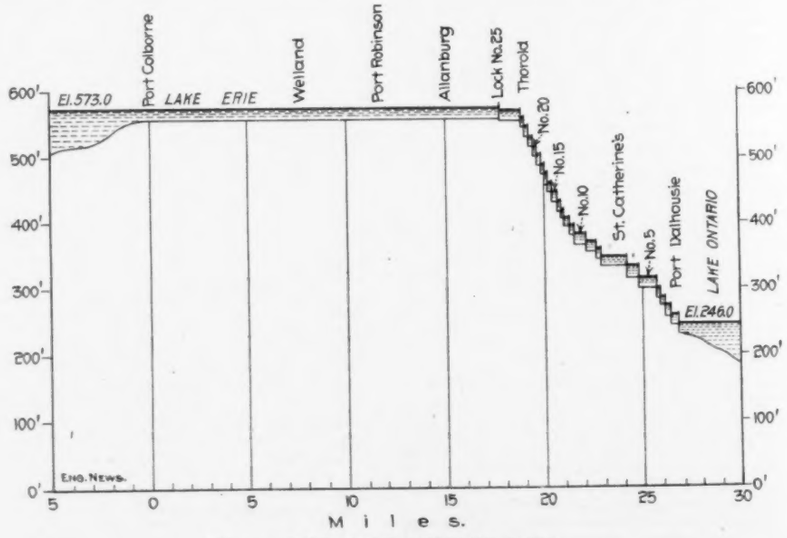


FIG. 2. PROFILE OF WELLAND CANAL.

	Tons of Freight. 1898.	1899.	Inc. or Dec.
Farm stock	0	10	Inc. 1
Forest produce of wd	140,031	103,589	Dec. 36,442
Manufactures	32,203	45,606	Inc. 13,403
Merchandise	235,364	178,042	Dec. 57,322
Agricult'l products..	732,470	462,523	Dec. 269,947
Total	1,140,077	789,770	Dec. 350,307
East bound	916,671	637,268	Dec. 279,403
West bound	223,406	152,502	Dec. 70,904
Total	1,140,077	789,770	Dec. 350,307

	Tolls.		
...rm stock	$1.14	$1.17 Inc.	$0.03
...ssels	22,228.79	15,405.22 Dec.	6,823.57
...ssengers	555.17	777.94 Inc.	222.77
...rest produce of wd	22,272.37	16,580.94 Dec.	5,691.43
...nufactures.	5,352.86	7,374.46 Inc.	2,021.60
...rchandise	41,766.36	28,639.59 Dec.	13,126.77
...ricultural products	76,421.38	49,254.61 Dec.	27,166.77
Total	$168,598.07	$118,033.93 Dec.	$50,564.14

The total number of vessels passing through the Welland Canal during the season of navigation in

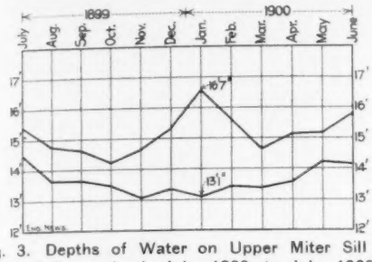


Fig. 3. Depths of Water on Upper Miter Sill of Port Colborne Lock, July, 1899, to July, 1900.

(The upper line shows the maximum for each month. The lower line shows the minimum.)

1898 was 2,384, representing a tonnage of 1,412,887. For the season of 1899, these figures were 2,202 vessels, with a tonnage of 1,060,673.

The usual through rates of toll are 1½ cts. per ton for steam, and 2¼ cts. per ton for sail and other vessels, the way rates being ⅛ to ½-ct. The rates for corn, wheat, flour, salt, iron and agricultural products generally are 15 cts. per ton although for the years 1898-99 a special rate of 10 cts. per ton for grain going east was made.

EXISTING WORKS AT THE LAKE ERIE ENTRANCE.

Port Colborne, Ont., the entrance of the Welland Canal, is situated on the north shore of Lake Erie, about 18 miles due west of Buffalo. The two entrance locks at the head of the Welland Canal are situated about ½ mile inland from the lake shore. The smaller lock has a length of 200 ft., with a width of 45 ft. The larger lock is of the same width, but has a length of 270 ft. The depth of water on the miter sill admits of the passage of vessels from 250 to 260 ft. in length, according to their beam, and drawing 14 ft., except on rare occasions of short duration, when heavy gales on Lake Erie lower the surface of the water. The maximum cargo that can be passed through the Welland Canal in a single vessel is from 2,000 to 2,200 tons, depending on the depth of water.

The accompanying diagram, Fig. 3, shows the fluctuations of the water surface of Lake Erie on the upper miter sill of the Port Colborne lock, between July, 1899, and June, 1900. The highest depth of water being 16 ft. 7 ins., and the lowest

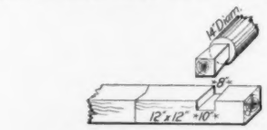
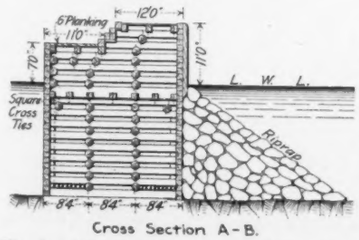


Fig. 6. Detail of Dovetails and Joints.



Cross Section A-B.

Fig. 5. Cross-Section of New Breakwater.

13 ft. 1 in., a range of 3 ft. 6 ins. This fluctuation is caused by the winds, a heavy southwest wind causing the water to rise, and a heavy east wind depressing it.

Between the head of the above-mentioned locks and the lake shore is an area termed the Welland canal basin, which is 2,200 ft. long and from 200 to 300 ft. wide.

Extending out into the lake, and at a slight angle with the west side of the basin, is a timber pier, 2,108 ft. long, and having a width of 30 ft.

At the outer end is an enlargement 60 ft. square, on which a lighthouse is located. This pier serves as a breakwater to protect the basin from southwest storms. There is also another timber structure, known as the East Pier, jutting out into the lake 510 ft. On the general line of the East Pier, but deflecting somewhat from it to the west, there are four detached blocks of crib-work, each block being 120 ft. long and 30 ft. wide. These blocks are about 250 ft. apart.

In continuance of the line of these blocks is an octagonal beacon, measuring 50 ft. on the diagonals at the bottom and about 20 ft. high above lake level. This is surmounted by a frame structure with a ball on the top of it, 47 ft. above lake level, and marks the point of a reef jutting out into the lake from the east side of the harbor.

The west, east piers and blocks of crib-work and the beacon just described form the present entrance to the Welland canal basin, the depth of

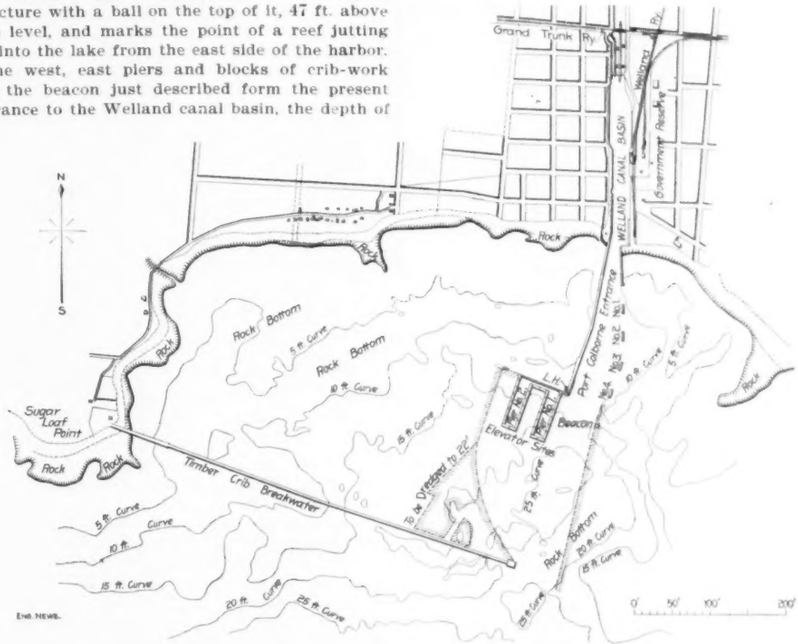


FIG. 4. MAP OF PORT COLBORNE, ONT., SHOWING PROPOSED IMPROVEMENTS.

water below M. L. W. L. being generally from 16 to 17 ft. Fig. 4, which is a map of a part of the canal entrance at Port Colborne, and the outer harbor, shows the existing works, and the contemplated improvements.

THE NEW BREAKWATER.

The location of this breakwater is clearly indicated on Fig. 4. The breakwater is to be 5,700

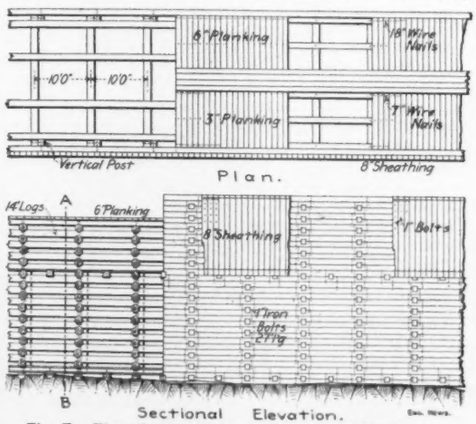


Fig. 7. Elevation and Plan of Portion of Breakwater.

ft. long, 25 ft. wide, including an embankment for the shore end 800 ft. long, and also an outer block 100 ft. long and 60 ft. wide. The breakwater for a length of 2,000 ft. westerly from the "Outer Block" is to be riprapped with stone along its outer face, as seen by the map. The breakwater is not straight, but has a slight angle near the middle.

The depth of water at the outer end of the breakwater is 22 ft., gradually decreasing towards the shore. The outer end of the breakwater is located on a line which is the prolongation of the west pier, the distance or opening being about 2,300 ft.

The breakwater will consist of 48 separate cribs (not including the outer block), each 100 ft. long and 25 ft. wide, and of varying heights, according to the depth of water.

The superstructure is continuous, consisting of a banquette, 10 ft. wide, with the top 7 ft. above O. L. W. level. The parapet is 12 ft. wide and 11 ft. above O. L. W. level. The two parts are connected by a series of 3 steps, each 1 ft. high and 1 ft. wide.

The whole work is built of square timber laid close, with cross-ties and longitudinals of round timber. The joints of the face timbers are made by butting the timbers against each other, as shown by Figs. 5 to 7. Gains or notches are cut to receive the tie-heads, or dovetails of the cross and longitudinal ties. These dovetails are 10 ins. square at the outer end, or at the face of the walls, and measure 8 ins. square at the throat. At the corners of the cribs the face timbers lap accurately. The face timbers are bolted every 10 ft. with 1-in. round iron bolts 27 ins. in length. The bolts are driven on alternate sides of all dovetails or tie-heads, so as to take 3 ties; on no account are bolts driven through a dovetail or corner half lap.

The cross-ties, where not otherwise shown, are of round logs, 14 ins. in diameter at the small end, and are placed 10 ft. apart, except the middle and bottom tiers, which are spaced 5 ft. c. to c. The cross-ties of the bottom tiers are all round timbers, while the additional cross-ties of the middle tier are square timbers 12 × 12 ins. The cross-ties in the breakwater proper are in one length, and extend from side to side.

The longitudinal ties are placed as shown, and are of the same diameter as the cross-ties, and in lengths of 22 ft., laid so that the ends lap on the cross-ties. The middle tier of longitudinals are square 12 × 12-in. timbers. Where cross-ties and longitudinals intersect they are carefully fitted, and bolted with 1-in. round bolts, 24 ins. long.

A ballast floor is partly laid on the first tier of timber, and consists of hemlock or spruce spars not less than 7 ins. in diameter at the small end, 25 and 30 ft. in length, laid heads and points. They are secured by ⅝-in. round bolts 16 ins. long. Vertical posts or timbers, 12 × 12 ins., extending from the bottom of the work to the height of the middle tier of square timber cross-ties are placed

every 10 ft., and bolted to every alternate face timber of the wall, and to every cross-tie, with 1-in. screw bolts.

The floor stringers are square timbers, 12 × 12 ins. The decking of the parapet and banquette is 6 ins., and laid at right angles to the axis of the breakwater. The decking is securely fastened to the floor stringers with wire nails 12 ins. long.

The whole of the outer face of the breakwater is sheathed with rock elm timber, 8 × 12 ins., and extending from 3 ft. below O. L. W. level to the top of the work; ¾-in. iron bolts 18 ins. long are used to secure this sheathing.

The whole of the work is filled to the underside

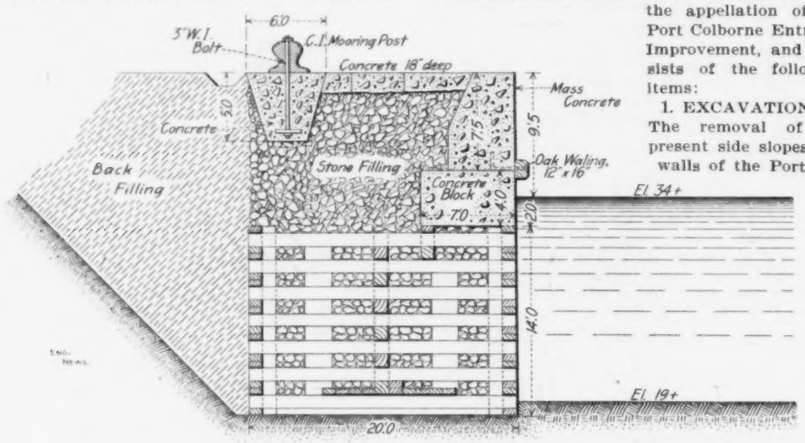


FIG. 8. SECTION OF CONCRETE RETAINING WALLS FOR THE WELLAND CANAL BASIN.

of the decking with stone, no piece exceeding 2 cu. ft. This stone filling is obtained from the excavation along the inner face of the breakwater.

The timber used from the bottom up to 3 ft. below ordinary low water level is spruce, hemlock, tamarack, white or red pine. Above that level, with the exception of the sheathing of rock elm, the timber used is either tamarack, white, red or pitch pine. The outer block is 100 ft. long and 60 ft. wide, built to an elevation of 13 ft. above O. L. W. level. The construction details of this block are similar to that of the breakwater proper. The three exposed corners of the outer block are protected by iron return plates over the sheathing, and extending from 1 ft. below O. L. W. level in 1 ft. within the top. The plates are ½-in. thick, fastened with 1-in. round countersunk bolts 9 ins. long.

The cribs are built on ways, 7 courses high, and then launched, and built up in the water as many courses high as they could be floated out of the Welland canal basin, at the south end of which the launching ways are located. Usually 18 or 20 courses were placed (this for the deep cribs), depending on the dryness of the timber, before being towed to the breakwater site. The remaining courses were all framed so that the crib could be made ready and finished as soon as possible after reaching deep water.

The first breakwater crib was sunk August 19, 1901, it being the 25 × 100-ft. crib furthest east, or adjoining the head block. The other cribs were placed in quick succession, and on Sept. 6, 1901, the 9th crib was placed, as also the head block. A severe storm occurred on Sept. 16, 1901, which dislodged crib No. 9, causing it to come ashore.

The cribs, after being carefully alined, are sunk in place, the bottom of the cribs resting upon the natural lake bottom. This sinking is attained by building temporary platforms on the tops of the cribs, on which the loading material is placed. Large concrete blocks, 4 × 4½ × 7 ft. in size, and weighing over 9 tons, were utilized for this purpose. After the cribs had become firmly seated on the bottom, the stone filling was deposited and continued until they were filled. The building of the superstructure followed soon after, and at this writing the head block and 800 linear ft. of breakwater are completed.

The shore end of the breakwater is to consist of a stone embankment 800 ft. long. It is to have a top width of 25 ft., with side slopes of 1 on 1½.

The slopes are to be of large stone carefully laid, and the hearting is to be dumped in; the top to be covered with a layer of broken stone, not exceeding 2 ins. in diameter, to serve as a road. The completed embankment will stand at an elevation of 7 ft. above O. L. W. datum. The material for this embankment is obtained from the same area of excavation as the breakwater filling and riprap. This area is to be excavated to a clear depth of 22 ft. below the level of O. L. W. The material to be removed is all solid rock.

IMPROVEMENT OF THE CANAL ENTRANCE.

The work under the direction of the Department of Railways and Canals is known officially under the appellation of the Port Colborne Entrance Improvement, and consists of the following items:

1. EXCAVATION. (a) The removal of the present side slopes and walls of the Port Colborne basin, cleaning up the bottom of this basin and adjoining outer harbor entrance for its entire length and width, from the locks to the south end of the west pier, to a depth of 15 ft. near the locks, and to 16 ft. at the south end of the basin, this latter depth continuing to a point near the south end of the west pier. (b) The deepening of the outer harbor seaward from the south end of the west pier to a depth of 22 ft., the southern limit of this excavation being the 22-ft. curve. (c) The removal of a strip of rock adjoining the west pier on the east side, affording 16 ft. of water along its face.

2. DOCKING. Formed of submerged cribwork, surmounted by a concrete wall, and backed up with stone filling, on both sides of the Port Colborne Basin, and at the southern end of the west pier, this latter work to serve as elevator sites.

3. DEEPENING of the rock section of the summit level of the Welland Canal, between the Port Colborne locks and Humberstone.

4. DEEPENING of the earth section of the same summit level between Humberstone and Allenburg.

Referring to the proposed docks at the southern end of the west pier, these are to form elevator sites, and consist of two parallel piers, whose outside dimensions are each 200 ft. wide and 700 ft. long, and between which a slip or basin 200 ft. wide and 600 ft. long is located, this basin having but one entrance, being closed at the other end. The piers are composed, as stated above, of timber cribs, surmounted along the outer edge with a concrete retaining wall, with stone filling behind it. The work may be termed an extension of the west pier, which it adjoins. The general location of the same is fully shown on the map, Fig. 4.

The object of these piers is to allow the largest class of vessels now plying on the Great Lakes to run alongside of them and unload their cargoes of grain into elevators to be built on these piers. This grain would in turn be transferred into vessels of smaller size, and of such capacity as would readily pass the Welland Canal locks, this capacity now being, as stated above, from 2,000 to 2,200 tons, or from 66,666 to 73,333 bushels of wheat.

The steamer "Aragon," whose length is 247 ft., beam 42.6 ft., has passed through the canal, drawing 14 ft. of water and carrying 2,212 tons of corn. At the present time vessels arriving at Port Colborne, and carrying a cargo in excess [illegible] or drawing over 14 ft. of water, have to be [illegible]ered at the Welland Railway elevator, [illegible] located on the east side of the Welland [illegible] basin, the excess cargo being carried by [illegible] Port Dalhousie, on Lake Ontario, where it [illegible] is retransferred to the vessel. This lighterage [illegible] some cases amounts to 20,000 bushels for a single vessel. The transfer capacity of the Port Colborne elevator is about 5,000 bushels per hour. The cost of lighterage is 2 cts. per bushel.

The cribs resemble generally those used in the construction of the outer breakwater by the Department of Public Works, there being, however, some variations in details. All timbers, except the grillage, are 12 × 12 ins., no round timber being used; this includes side and end wales, cross and longitudinal ties and vertical posts, the latter being placed at the corners and at 20-ft. intervals in which latter case they abut against the side walls as well as against the cross-ties. They are secured to the adjoining timbers by 1¼-in. round screw bolts.

The three bottom courses of the cribs are connected by means of screw bolts, the remaining courses are secured to one another by 1¼-in. round drift bolts passing wholly through two courses of timber, and 8 ins. into the third one. The corners are square-cut lap joints, the side and end timbers passing over each other alternately. The first or lower tiers of cross-ties is spaced 5 ft. c. to c., the grillage or ballast floor resting upon the same.

As the bottom of these lower cross-ties is 6 ins. above the bottom of the side and end walls, a 6 × 12-in. packing piece is spiked to the under side. This is very important, and prevents settlement of the interior portion of the crib when filled with stone. The tops of the cribs are sunk so as to be 2 ft. below an assumed water surface, which is 14 ft. above the top of the south miter sill of the new lock at Port Colborne.

The construction of the cribs forming the east and west sides of the Welland canal basin are similar in design to those of the elevator piers. A considerable portion of this latter work has been completed.

The old side slopes and walls were removed by dredges, as also the material below water level to the required depth. The cribs rest immediately upon the foundation so dredged. After being

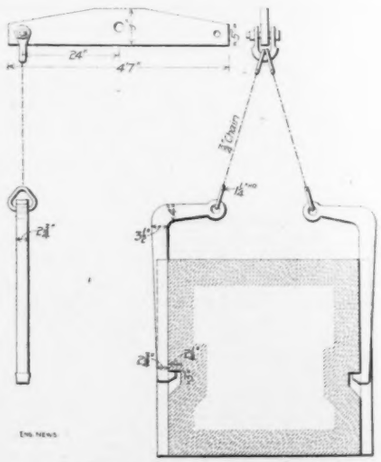


Fig. 9. Hooks for Lifting Concrete Blocks.

floated into position and properly alined, they are loaded with large blocks of concrete and when at the proper level are filled with rubble stone.

The retaining wall on top of the crib consists of concrete molded to the prescribed cross-section, and founded on concrete blocks. This wall on one side forms the eastern limit of West St., while on the other side it forms the support of the towing path, wharf and railroad tracks connected with the Grand Trunk Railway (Welland branch) transfer elevator. Fig. 8 is a cross-section of this wall, showing its actual construction on top of the cribs. The concrete blocks are 7 ft. long, 4½ ft. wide, and 4 ft. high. There are two joggles on

of the long sides of the block extending from top to the bottom. When the blocks are placed side by side, the respective joggles are in juxtaposition, and are filled with concrete, forming dry joggle joints, tending to prevent lateral movement of the blocks.

The bottom of the blocks is placed 2 ft. below L. W. level, the front edge resting upon the top of the front crib wall, and the back of the blocks upon an auxiliary timber wall composed of two longitudinals, each 12 × 12 ins., in cross-section, and one longitudinal 6 × 12 ins., in cross-section. In this connection attention is invited to the short filling blocks between the cross-ties of the cribs. They being almost directly in a line under the back edge of the concrete blocks, prevent any deformation of the ties under load and thus prevent settlement of the retaining wall.

The blocks are handled by means of special hooks, which are shown in Fig. 9.

There are four hooks in all, arranged in pairs, each pair being suspended from the ends of a balance beam. This balance beam is 4 ft 7 ins. long, 2 ins. thick, 5 ins. deep at the ends, and 9 ins. wide at the middle. The hooks are 2¾ ins. thick, 3½ ins. wide, tapering to 2¾ ins. at the bottom, they being bent at right angles, forming a short hook.

Recesses are formed in the joggles, in which the bent ends of the hooks engage, allowing the blocks to be handled with ease, and without any damage to them. The remainder of the wall is mass concrete, built within suitable timber forms, attached to the blocks by temporary bolts.

The composition of the concrete is 1 part Portland cement, 2 sand and 4 broken stone. The cement used almost exclusively was the Atlas, made by the Atlas Portland Cement Co., of 30 Broad St., New York. The mass concrete was made by means of gravity mixer, made by the Contractors' Plant Co., of Boston, Mass.

The plant for making concrete blocks is located on the west side of the Welland Canal, a short distance north of the crossing of the Grand Trunk Railway. The canal here was excavated through solid rock, and the excavated material forms huge spoil banks on either side of the canal.

The concrete plant consists essentially of a Gates stone-crusher, a Cockburn mixer, and a long line of elevated trestle, from which the mixed material is deposited into molds or forms. The stone is quarried from the spoil banks by means of bars and picks, and is hauled to the crusher in carts. The stone, after passing through the crusher, drops into a skip; the latter when filled is swung by a derrick to the mixing platform,

Fig. 10. End View of Concrete Retaining Wall, Showing Concrete Blocks Resting on Submerged Cribs and Mass Concrete Superstructure.

containing the Cockburn mixer. The sand and cement are delivered on the platforms by wagons. The proper proportions of the different materials having been measured out, they are fed into a hopper, thence passing through the mixer are deposited into iron dump-cars, which are drawn by horses along the track laid on the elevated trestle mentioned above. The molds or forms are built alongside this trestle, with the tops a short distance below the level of the rails. This arrangement allows the mixed concrete to be readily and quickly deposited. The completed blocks are transferred to a scow by means of a floating derrick, and are then transported to the work by a tug.

To the uninitiated who do not understand why the walls should not be built wholly of mass concrete, it may be said that the use of blocks obviates the placing of green concrete under water, an operation not usually attended with satisfactory results, as to first-class work.

Fig. 11. Molded 9-ton Concrete Blocks Ready for Placing.

For excavating the solid rock above the fixed grade lines, 3 submarine drill boats are employed. These boats consist of heavily-built hulls, covered over, in which the boiler, engines, steam pumps and blacksmith shop are housed. The drill boats are anchored and held in position by large spuds. The derrick frames, mounted on trucks, are propelled longitudinally over a suitable track. The drill frames carry the steam drills, which are operated much in the same manner as land drills. The spacing of the drill holes depends much on the depth and character of the rock and other contingencies. The resulting holes are loaded by means of a loading pipe, dynamite being used as as explosive. The resulting broken rock is dredged up, the contractors having 3 dredges in use, 2 with 4-yard buckets and 1 with a 2-yard bucket.

Much of the material dredged out for the retaining walls of the Welland canal basin was loaded into steel tubs of 5 cu. yds. capacity, carried on large deck scows. These buckets are handled by floating derricks, of which there are two, one a steel derrick of 20 tons capacity, the other a timber derrick of 10 tons capacity. This material was used to back-fill behind the completed concrete retaining walls, and was thus utilized with a minimum amount of handling. In addition, the contractors have a number of dump scows, floating derricks and other plant for handling timber and concrete materials.

The estimated cost of the work is as follows:

Port Colborne breakwater	$400,000
Port Colborne entrance improvements	1,000,000
Deepening Welland Canal—Port Colborne to Humberstone (rock)	80,000
Humberstone to Thorold (earth)	30,000
Lowering large lock, Welland Canal, Port Colborne	15,000
Total estimated cost	$1,525,000

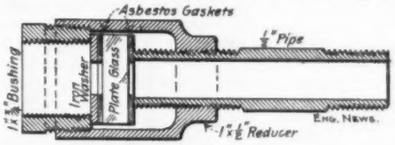
All the work is in a well advanced stage, and will likely be completed during the season of 1902.

The work of lowering the large lock at Port Colborne is also under way (January, 1902), and consists mainly of lowering the floor of the lock, as also the miter sills, 3 ft., which will give ordinarily 17 ft. of water over the same. The lock is founded on solid rock. The work of lowering the floor is done in the dry, the water having been pumped out of the lock for this purpose, temporary cofferdams being put in at each end.

A DEVICE FOR EXAMINING THE INTERIOR OF GAS ENGINE CYLINDERS WHILE RUNNING.*

By Wm. T. Magruder,† M. Am. Soc. M. E.

The books contain many theoretical discussions concerning what goes on inside of a gas engine after the ignition, and as to whether the gas and air are exploded and combined instantaneously, or whether they burn through a large part of the stroke, and also whether they are stratified or burned by layers. The gas engine indicator gives us a more or less correct record of the various pressures obtained during the different strokes. By counting the number of "misses" in a unit of time when the engine is running under constant load with different proportions of fuel to air according to the settings of the inlet valves, we can form some opinion as to the efficiency of the combustion. Persons familiar with the use of the Bunsen burner either in the chemical laboratory or with natural gas know that by properly adjusting the proportion of air to gas a hotter flame can be obtained. The proper proportion is determined by the appearance of the flame, a blue flame being a much hotter one than a yellow flame, the former indicating complete combustion, the latter indicating the presence of incandescent carbon. To do this with an open gas flame is quite an easy task, but to do it under pressures of from 200 to 400 lbs. is quite another matter. We illustrate herewith a very simple piece of apparatus for doing the same thing in a gas engine cylinder. Preferably into the rear head is screwed a pipe nipple, say ½-in. iron pipe size, and having a long thread on one end which is screwed into a 1 × ½-in. reducer in whose outer end is screwed a 1 × ¾-in. bushing used as a stuffing-box nut in holding a piece of thick plate glass in position at the end of the ½-in. nipple. The glass is separated from the nipple and the iron stuffing-box washer by means of asbestos gaskets. To keep the glass from becoming overheated and possibly breaking, its distance from the inner side of the cylinder head should be several inches. It should also be so small in diameter as not to touch the inside of the reducer. The strength of the plate glass is ample for the pressures which come upon it when mounted as here shown. The chief danger of breakage is from overheating and undue expansion. With this piece of apparatus we have viewed the interior of a gas engine while it was running and



A "Combustion Sight-Hole" for Gas Engine Cylinders.

gained much information as to the combustion of the charge by so doing. While we have never yet broken the plate glass, we would advise the user not to put his eye too close to the end, but to stand off a few feet, at which distance just as much can be seen and the possibility of personal damage will then be removed. The cost of the apparatus is under a dollar, and we think it is well worth a trial, not only by the curious, but by those whose business it is to test gas engines.

THE RANGE OF TIDES IN THE BAY OF FUNDY.

The last issued report on Survey of Tides and Currents in Canadian Waters, by W. Bell Dawson, C. E., Ottawa, Canada, contains some interesting notes upon the famous tides of the Bay of Fundy. From the figures given, it is evident that while the range of tide in the Bay of Fundy is remarkably great, the height of these tides has been much exaggerated.

Taking as datum a bench-mark established by the engineers of the Chignecto Marine Transport Railway, Mr. Bell finds the following levels of extreme high and low tides in Cumberland Basin, head of the Bay of Fundy:

	Above datum, ft.
Oct. 5, 1869.—Extreme high tide in heavy storm	100
1893.—Highest H. W. in 5 mos., Aug. to Dec.	96
Lowest L. W. in 5 mos., Aug. to Dec.	47
Oct. 8, 1896.—Exceptional H. W.	96.13
Nov. 7, 1900.—Exceptional H. W.	96.68
1898.—For 4½ months, mean H. W.	89
For 4½ months, mean L. W.	52.59

Mr. Bell says that during four consecutive months the average range of the tides was as follows:

Spring tides, near time of moon's perigee	47.58 ft.
Spring tides, near time of moon's apogee	37.20 "
Neap tides, general average	31.00 "

From the lowest low water recorded to the highest tide ever known, the extreme difference of level is 53 ft.

*Reprinted from "The Gas Engine," for March.

†Professor of Mechanical Engineering, Ohio State University, 191 King Ave., Columbus, O.

THE KENNICOTT WATER SOFTENING SYSTEM.

One of the most general troubles incident to the use of boilers is that caused by the formation of scale by the use of hard water; the scale reducing the efficiency of the boiler, and involving expense and delay in removing the scale to keep the boiler in safe and efficient service. The scale and the work of removing it also tend to injure the boiler and to shorten its life. These conditions are particularly troublesome in locomotive boilers, which have generally to use such water as is available at locations where water stations are necessary. Various systems have been introduced for treating the water in the boilers by the addition of certain chemicals, etc., while other systems for detaching and blowing off the scale are also in use. The most effective and economical method, however, would certainly appear to be to treat the water before it enters the boilers. Different methods of this kind are now in satisfactory service, and it seems probable that their use will be extended, as the troubles and expense due to scale within the boilers come to be more generally appreciated.

The Kennicott system of softening water consists in the addition of soda and lime solutions of such strength as may be required by the quality of the "raw" water, and this treatment is then supplemented by the sedimentation of the treated water. The water from the source of supply is delivered into the hard-water box, A, above the top of the settling tank, and from this it passes through a slot in the bottom, the size of the slot being adjusted according to the amount of water to be treated. Within this box is a float, with chains passing over pulleys and connected to hinged inlet pipes in the two boxes or small tanks, B and C, which contain soft water, and the soda solution, respectively. The object of this arrangement, which is shown in Fig. 1, is to vary the supply from these tanks, in accordance with the supply of raw water. Thus, if the rapidity of the supply increases so as to maintain a depth of 6 ins. in the box, A, or a head of 6 ins. over the slot in the bottom of the box, the rising of the float will allow the ends of the hinged inlet pipes to drop 6 ins. below the surface of the respective tanks, thus maintaining a constant uniform head. The ends of these hinged inlet pipes are closed with caps, each cap having a small slot of such size as to give the required proportion of solution to the water. This, of course, is varied according to the character of the water to be treated.

Fig. 2 is a sectional elevation, and Fig. 3 a plan of the complete plant. The hard or raw water passing through the slot in the bottom of the tank, A, falls upon a water wheel, D, and thence upon the perforated mixing plate, E, at which point the lime and soda solutions are added. The water then enters the top of the settling cone,

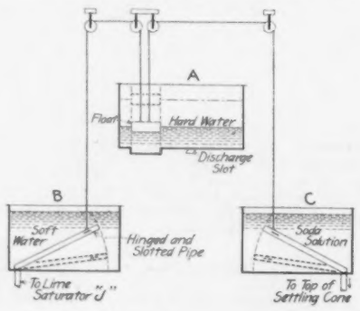


Fig. 1. Graduating Arrangement for Kennicott Water Softening Apparatus.

in which its velocity continually decreases, causing the particles held in solution to fall to the bottom of the cone, the larger particles serving to carry the smaller ones with them. On reaching the bottom of the tank, the current is reversed, and the water rises through a series of perforated conical baffle plates, F. At the same time the velocity still decreases, owing to the increasing diameter of the water space. On reaching the top, the water passes upward through a filter compartment, G, filled with wood fiber, and enters a shallow soft-water tank, H, from which it flows to the storage tank for supplying the boilers. At the bottom of the settling tank is a conical hopper with valve for discharging or blowing out the sediment.

The lime solution is prepared in a vertical saturator or tank, J, which is usually at the side of the settling tank, but is in some cases placed

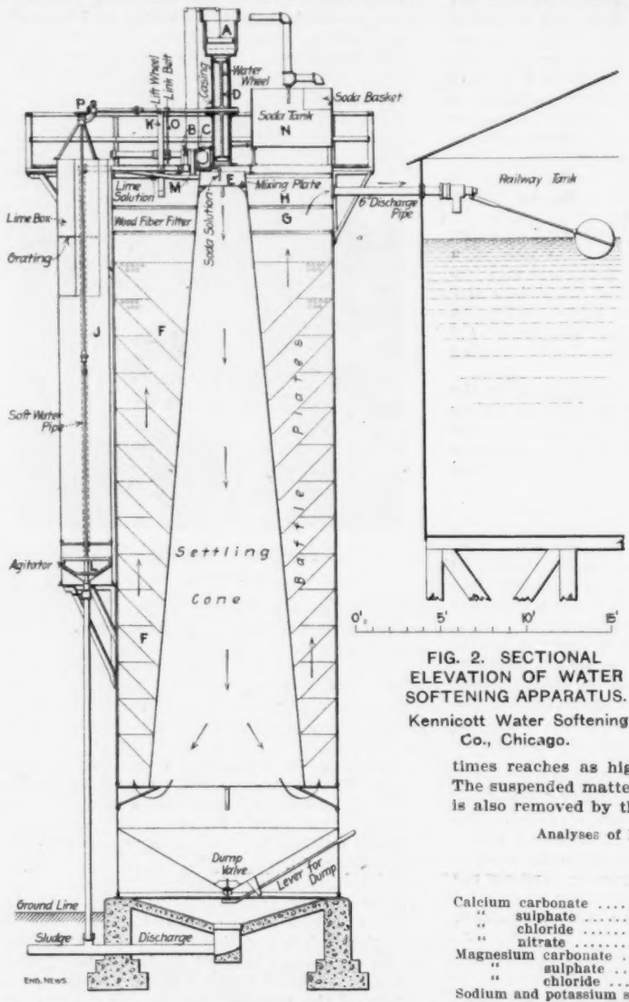


FIG. 2. SECTIONAL ELEVATION OF WATER SOFTENING APPARATUS.
Kennicott Water Softening Co., Chicago.

within this tank to prevent freezing. The lime is placed on a grating near the top of the chamber, and soft water from the tank, H, is used for dissolving the lime. This water is raised by a wheel, K, having hollow curved arms, open at the ends, which dip into the water; the water flowing through the arms into the hollow shaft and thence into the tank, B, from which its flow to the saturator is regulated by the hinged inlet pipe already described. The soft water is piped to the lime box and thence to the bottom of the saturator, where it is stirred by an agitator or paddle, L, to thoroughly mix it, after which it rises in the cylinder and finally overflows through a trough, M, leading to the mixing plate, E, where it mingles with the raw water and the soda solution. The delivery, being by overflow, is always equal to the amount of soft water delivered to the saturator. The soda is placed in wire baskets in two tanks, N, N, from which the soda solution tank, C, is filled by gravity. The supply of water to the tanks, N, is controlled by ball cocks and floats.

The water wheel, D, drives the lift wheel, K, by a link belt, O, on its shaft, and also drives the shaft of the agitator, L, by means of the bevel gear, P. The water wheel shaft has also a drum, operated by a clutch, which is used for hoisting the lime supply. The flow of the raw water supply is therefore utilized to operate all the mechanism connected with the apparatus.

The first Kennicott plant was installed in 1899 at the works of the Consumers' Co., Chi... This plant treats Lake Michigan water, and ...ving very satisfactory results. Although the ...ater is not ordinarily considered a very hard ..., it still forms a considerable quantity of ...mely hard scale. The boilers at these works ... been in use some eight years when this softe... plant was installed. There are nine 125-HP. r...-flue boilers, with eigh... se at one time. It had ... the custom to clean ... oiler once in two weeks, ... man going into the b... with a hammer and pi... t off such scale as ... could reach, after wh... the boiler was th...ghly washed out with ... hose. Boiler compounds ... been abandoned a ... of years previously, ... success having been ...ained after using compo...ds for a number of years, ... practically since the ...stallation of the boilers. About 1/8-in. of extremely hard scale had been formed upon the tubes, while upon the head near the point of entry of the water in some boilers the scale had attained a thickness of 1/2-in.

The cost of treatment is about 1/2-ct. per 1,000 gallons of water. The accompanying analyses of the water before and after treatment were made at the time when Lake Michigan was very clear and free from suspended matter, so that the analysis before treatment does not include any suspended matter, which at the time of the spring storms sometimes reaches as high as five grains per gallon. The suspended matter, when present in the water, is also removed by the process.

Analyses of Lake Michigan Water.

	Grains per U. S. gallon.	
	Before treatment.	After treatment
Calcium carbonate	4.02	0.88
" sulphate	None.	0.21
" chloride	None.	None.
" nitrate	None.	None.
Magnesium carbonate	1.88	1.17
" sulphate	0.50	Trace.
" chloride	None.	None.
Sodium and potassium sulphates	1.14	1.79
" " " chlorides	0.41	0.41
" " " carbonates	None.	None.
Oxides of iron and alumina	Not deter.	Not deter.
Dissolved carbonic acid	....	....
Silica	0.35	0.19
Reaction	Alkaline.	Alkaline.
Suspended matter	....	....
Scale forming solids	6.75	2.45
Non-scale forming solids	1.55	2.20

Within two weeks from the installation of the softener and the use of softened water the scale commenced to come away from the boilers, and within five months' time the boilers were practically free from scale. Scale which had formed in the exhaust heaters did not commence to come away for several months, and was not entirely removed until about a year had elapsed. The action of the soft water upon the scale on the heaters was very interesting. The scale was in some cases nearly 1 in. thick; it gradually became honey-combed and soft, a thin skin of hard scale next the iron remaining. This soft scale then commenced to drop from the tubes in the heaters and attention was called to it by the stoppage of the heaters, due to this mass of scale falling away.

In regard to the economy of using the water softening apparatus, the Everett Audit Co., of Chicago, made an examination of the books and reported that the records showed an actual reduction of coal consumed at the factory per ton of block ice produced as follows:

With purifier	Without purifier	Saving
April, 1900, over	April, 1899	17.43%
May, 1900, "	May, 1899	15.65%
Average for two months		16.63%

These figures were based upon the amount of ice produced and the amount of coal required to produce it. The kind of coal used in each year was the same, and the boilers and ice machines were in the same condition, except that the boilers were scaled one year and not scaled the other year. The labor required to operate the machine is very small; an engineer or an assistant visits the machine every six hours to put lime in the lime saturator and a fresh tank of soda is prepared every 24 hours. The blowing-out of the accumulated sludge at the bottom of the machine requires only a minute's time. This plant has a capacity of 5,000 gallons per hour.

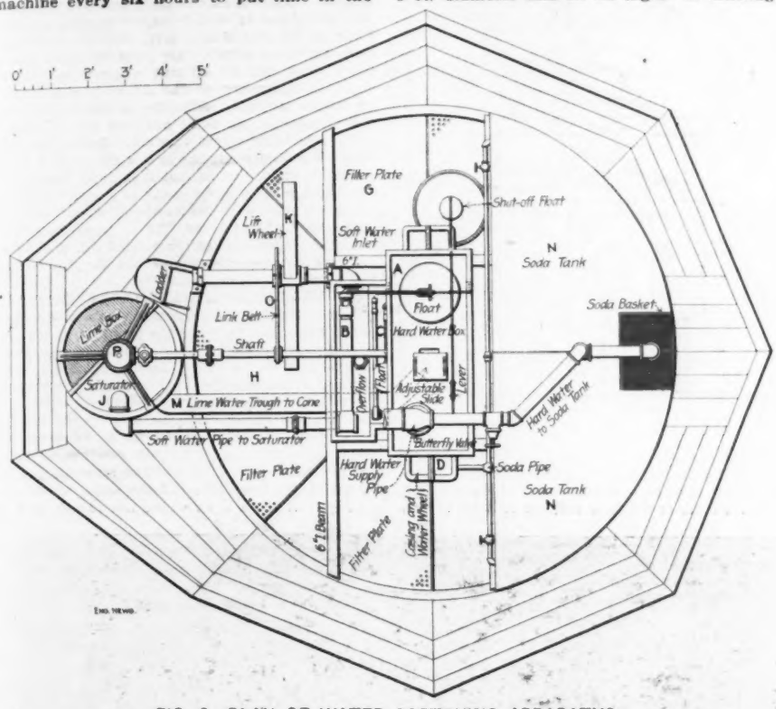


FIG. 3. PLAN OF WATER SOFTENING APPARATUS.

The apparatus has also been installed at the boiler plants of works at Cairo, Ill., and elsewhere; and it is also being tried by a number of railways for their water stations, one of the first being that at Point of Rocks, Wyo., on the Union Pacific Ry., and another at Buda, Ill., on the Chicago, Burlington & Quincy R. R. The latter plant

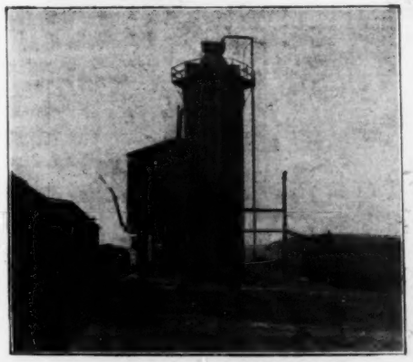


Fig. 4. Kennicott Water Softening Plant at Point of Rocks, Wyo.; Union Pacific Ry.

treats 9,500 gallons per hour. At Buda the water supply is obtained from a creek which is fed mostly by springs, but in wet weather it is also fed largely by surface water. The analysis shows 17 or 18 grains of scale-producing matter per gallon in dry weather, and in wet weather this will run down to below 10 grains. When the raw water was uniformly showing 18 grains per gallon, the treated water showed about 6 grains.

A view of the Point of Rocks plant is shown in Fig. 4, and this plant has a capacity of about 8,000 gallons per hour. The 6-in. supply pipe from the artesian wells extends up alongside the settling tank and discharges into the rectangular hard-water tank, below which may be seen the circular casing of the water wheel. The cylinder seen in front of the settling tank is the lime water tank, or saturator. The settling tank is 13 ft. diameter, and 43 ft. high, while the saturator is 3 ft. diameter and 25 ft. high. A hoisting arm or davit is shown on the platform, for raising the lime barrels, but in other plants a hoisting drum is used, driven from the water wheel, as already described. The plant supplies two 50,000-gallon tanks; the tank shown in the cut serves two tracks, one by a spout attached directly to the tank, and the other by a supply pipe carried by a frame to which the spout is attached. In the illustration, this latter spout is in use for filling water-tank cars, by which other stations are supplied with the soft water. These cars are steel gondola cars, properly calked and fitted with covers and splash boards. None of the engines taking water here use this water exclusively, but we are informed that the enginemen state that the scale begins to loosen within a few weeks after beginning to use the water, and that the condition of the boilers is much improved. The boiler in the pump house, which used the treated water exclusively, had the scale taken out of it in a few weeks and no new scale formed. When treating 150,000 gallons per day, 57 lbs. of soda and 1½ barrels of lime are used daily, the cost for chemicals being about 1 ct. per 1,000 gallons. The following analysis shows the quality of the water before and after treatment; even better results have been obtained at times, but not regularly:

Analyses of Water at Point-of-Rocks, Wyo.; U. P. Ry.
Grains per U. S. gallon.

	Before treatment.	After treatment.
Silica	0.79	0.40
Carbonate of lime	9.86	None.
Hydrate of lime	None.	3.45
Carbonate of magnesia	3.51	None.
Hydrate of magnesia	None.	0.20
Sulphate of magnesia	7.03	None.
Carbonate of soda	1.12	0.29
Sulphate of soda	4.70	7.80
Chloride of soda	16.48	14.49
Total solids	43.49	26.63
Incrusting solids	21.19	4.05

This system is the invention of Mr. Cass L. Kennicott, who is Vice-President and General Manager of the Kennicott Water Softener Co., 3567 Butler St., Chicago. The agency for railway water stations is held by the J. S. Toppan Co., Great Northern Building, Chicago.

COAST EROSION IN ENGLAND.

An interesting article on "The Lost Land of England," in quarterly volume No. 27 of "The Strand Magazine," describes in a popular way the steady and disastrous eating away of the coast line by the encroaching sea, and it is stated that the annual loss of area by coast erosion in England alone is probably not less than 2,000 acres. The total area of Great Britain, according to official figures, has been reduced from 56,964,260 acres in 1867, to 56,782,053 in 1900; in England alone it was reduced from 32,590,297 to 32,540,019 acres, a loss of over 40,000 acres. On the other hand, marsh lands have been drained and other lands reclaimed, but these areas are insignificant as compared with those which have been lost. Parts of the lost lands were low-lying, protected by dikes or levees, which were eventually breached; other parts were washed away by floods and storms; but in many cases the sea is eating its way into tall cliffs, demolishing numerous towns and villages.

The line of anchorage for ships off Selsey, in Sussex, is still called "the Park," having been a royal deer park in the reign of Henry VIII., while the treacherous shoals known as the Goodwin Sands formed in early days the estate of Earl Goodwin. Off the Yorkshire coast there are 12 buried towns and villages, and in Suffolk there are five. Submerged forests may be seen at low tide off Bexhill and Wirral, and their remains have been found at numerous points along the coast. Southwest from Land's End, toward the Scilly Islands, a peninsula of about 227 sq. miles has been carried away, and below the sand beach is a deposit of black mold containing indications of trees and deer. At Wirral is Leasowes Castle, now on the edge of the cliff, but 50 years ago it was half a mile from the sea. Many historical towns, such as Ravensburgh (mentioned by Shakespeare), where Henry IV. landed in 1399, and Edward IV. in 1471, have now entirely disappeared. At Reculver the cliffs were gradually eroded until a church, originally two miles inland, was partly wrecked; this church, however, had two spires forming a striking landmark for sailors, and the Trinity Board (in charge of the lighthouse work) therefore had a sea wall built to prevent the destruction of the towers. Historical records show that enormous losses have occurred, not only in the area of land eroded, but also in the destruction of towns and villages. Present observations show that the work of erosion is still active, and, as above noted, it is estimated that the country loses annually some 2,000 acres in area. At certain points steps have been taken to check the erosion, but as a rule it goes on practically unheeded.

AN ELECTRO-MAGNETIC GUN, invented by Professor Birkeland, has been experimented with at Christiania. The shell is drawn out of the bore, and not, as hitherto, impelled by gunpowder and the use of magnetism, according to the Professor, will enable 1,000-lb. projectiles to be hurled much farther than by the present methods. This is a hard saying.—Engineer, London, Feb. 14.

The Birkeland gun is probably constructed on the solenoid principle, which was long ago suggested for giving velocity to projectiles, but the operation of a gun on this principle to give a high velocity to a thousand-pound propectile is rather a large order. If, as the Professor claims, projectiles of this weight are to be hurled much farther than by the use of gunpowder they must have a greater velocity or a slightly less velocity and a greater value for $\frac{w}{d^2}$, —in other words, greater proportional length. Since the practicable increase of length is limited he must rely chiefly on increase in velocity. Let us assume a length of gun of 60 ft. and velocity of 3,000 ft. per second. This gives, with a projectile of 1,000 lbs., a muzzle energy of about 63,000 foot-tons. This enormous energy must be developed in a very small fraction of a second. The initial velocity of the projectile is zero and its muzzle velocity is 3,000 ft.; its mean velocity in the gun is therefore 1,500 ft., and it therefore requires .04 second to travel the length of the bore. The unknown electrical force acts .04 second, producing 63,000 foot-tons of work. In one minute it would, therefore, produce 94,500,000 foot-tons or about 6,300,000 HP. This seems a good deal of power to put in dynamos. If the gun tube were twice as long only about half as much power would be required. No question of the efficiency of the solenoid, dynamos, steam machinery, etc., is here considered.— Proc. U. S. Naval Institute.

TEST AND DYNAMOMETER CAR; CHICAGO, BURLINGTON & QUINCY R. R.

A number of leading railways are now using specially equipped cars for dynamometer and other tests, such as recording the drawbar pull of engines, analyzing the waste gases from the engines, and recording the condition of the track. The test car of the Chicago, Burlington & Quincy Ry. was described in Engineering News in 1893 (July-Dec., p. 299); that of the Cleveland, Cincinnati, Chicago & St. Louis Ry., in 1898 (July-Dec., p. 334); and that of the Illinois Central R. R. in 1900 (July-Dec., p. 71), and 1901 (July-Dec., p. 28). The car of the Chicago, Burlington & Quincy Ry. has recently been thoroughly overhauled and improved, and we are indebted to Mr. Max H. Wickhorst, Engineer of Tests, at Aurora, Ill., for drawings and particulars of the car and its present equipment.

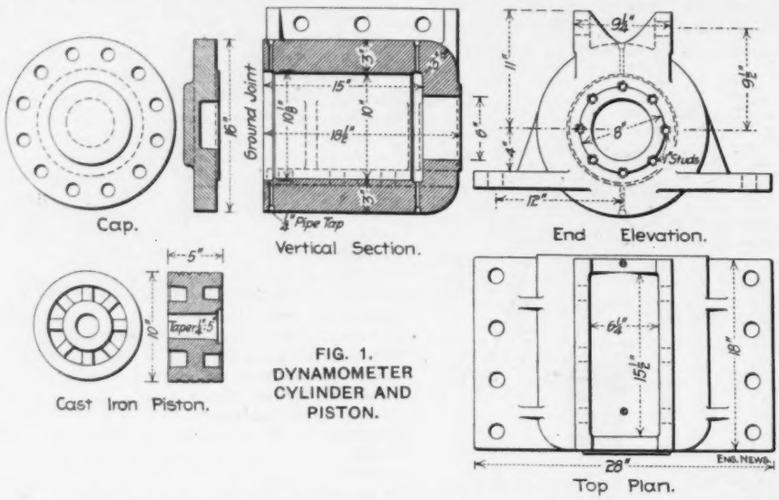


FIG. 1. DYNAMOMETER CYLINDER AND PISTON.

The car resembles the regular way cars or cabooses, and is mounted on a pair of four-wheel trucks. It is 30 ft. 9 ins. long over the sills, and 30 × 8½ ft. inside. It has a platform at each end, and a cupola at one end; this cupola is located over the recording table and will seat four persons. At one end of the car are the dynamometer, gage board, recording table, gas analysis apparatus, and work benches, while at the other end are seats and sleeping accommodations. The equipment includes the following: (1) An oil dynamometer for measuring train resistance; (2) an Orsat gas analysis apparatus for analyzing smokebox gases or products of combustion; (3) air brake recorder; (4) steam pressure recorder; (5) smokebox vacuum recorder; (6) Boyer speed recorder, and several electric counters. The most important part of the equipment consists of the dynamometer and the apparatus for gas analysis. The description of the hydraulic dynamometer, with its automatic recording mechanism, as sent us by Mr. Wickhorst, is given below:

DYNAMOMETER.—The dynamometer consists of an oil cylinder or oil "jack," 10 ins. diameter with a piston of 5 ins. face × 2½ ins. piston rod, and 4 ins. of free movement of piston. This is shown in Fig. 1. There is no packing around either the piston or rod, but both are ground to a fit, and are still free in movement. This makes an expensive construction, but does away with friction in the dynamometer. The cylinder is designed to withstand a pressure of at least 1,000 lbs. per sq. in., which is equivalent to a tractive pull of over 75,000 lbs. The general principle is the same as that used by Prof. L. P. Breckenridge of the University of Illinois,* but we have merely one piston and this is double acting; that is, suitable for either pull or push. When in testing service, the drag of the train comes on the cushion of oil and we arrange to take automatic record of the oil pressure thus developed. In addition to the oil cylinder, there is a twin spring draft arrangement which can be made to take the drag of the train, and thus cut the dynamometer and save any strain on it. To do this, it is simply necessary to open a by-pass to allow free circulation of the oil between the two ends of the cylinder, and put in filler blocks to fill in the space between the springs and encircling yoke.

DYNAMOMETER RECORDER.—The recording arrangement, Figs. 2 and 3, is somewhat similar in principle to a steam indicator, consisting of two cylinders 9-16-in. diameter, or about ¼ sq. in. area, placed on each end of a bedplate and the piston rod extending from one to the other. The piston rod is held in place by means of two springs, each under compression of half its capacity, the springs each having a seat on one end against one of the small cylinders and the other end against a sleeve fastened to the piston rod. The pressure then on either end of the piston rod will compress one spring and release the other. As one cylinder is piped to the front end of the dynamometer and the other to the back end, the recorder is thus made double acting. The movement of the piston rod is multiplied by means of a lever arm giving a multiplication of 10, and giving a straight-line motion with correct multiplication. The ordinate obtained with a given pressure may be varied by using springs of different capacity in the recorder and we aim to get an average ordinate of 3 or 4 ins. The records are taken by means of graphic pens, one of which draws a datum line [illegible] zero drawbar pull); this pen remains stationary [illegible] set before starting. The drawbar recording pen [illegible] ordinate varying with the drawbar pull or pressure [illegible] dynamometer.

PIPING.—Pipes lead from both ends of the both [illegible] dynamometer, and the pressure at either end can be shown on the high-pressure gage or on the low-pressure gage which also shows vaccum, or may also be led to the recorder. There is an oil-supply tank and a hand pump. This pump can be used to replenish the dynamometer while on the road if necessary, although practically this necessity never occurs. Air pipes are used for returning the oil back into the oil tank whenever it is desired to drain the dynamometer. The air can be obtained from the air supply attached to the pipe system in the car, or it may be obtained from the auxiliary reservoir under the car, a pipe being tapped into this. Each of the pipes from the dynamometer has in it a check valve with a scratch on its seat so that it is never perfectly closed and which relieves any vacuum or pressure that may occur in the end not in use for recording pull or push. For convenience of distinction, the oil pipes from the front end of the dynamometer are painted red, and those from the back end are painted blue; the air pipes are painted green, and other pipes black.

CALIBRATION OF DYNAMOMETER.—For the purpose of calibrating the dynamometer we use a dead weight gage tester which is tapped into the pipe system and arranged so that pressure can be obtained in either the front end or back end of the recorder. Before calibrating, the apparatus is all put together and the datum pen properly set. To test the datum line, the recording pen is forced to one side and allowed to come back slowly and the bedplate of the recorder tapped with a couple of mallets while the paper is pulled through slowly until the recording pen becomes stationary. The recording pen is then forced to the other side and the same procedure gone through. If there is no undue lost motion, and the recording piston has no undue friction, the two lines thus obtained will very nearly coincide. The valves are now opened so that pressure produced by the gage tester is brought to one end of the recorder while the other end is opened free to the atmosphere, care being taken to have the gage tester brought level with the recorder, or else to

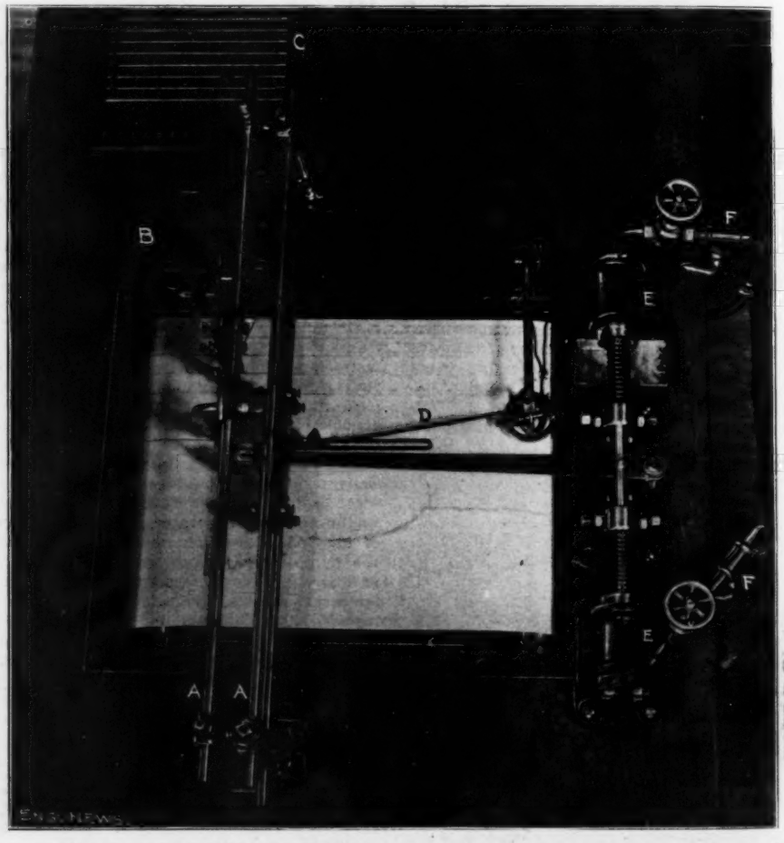
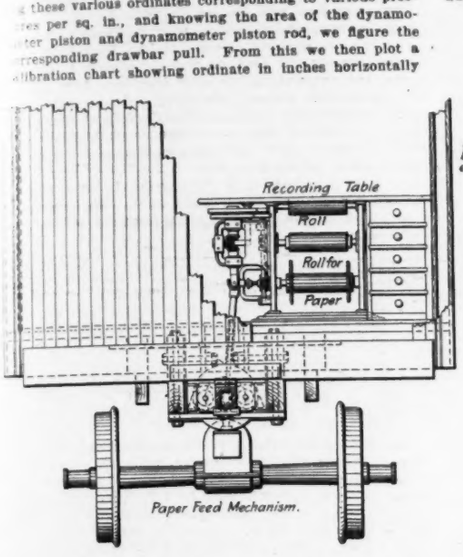


FIG. 2. PLAN VIEW OF RECORDING APPARATUS OF DYNAMOMETER CAR; CHICAGO, BURLINGTON & QUINCY R. R.
Max H. Wickhorst, Engineer of Tests.

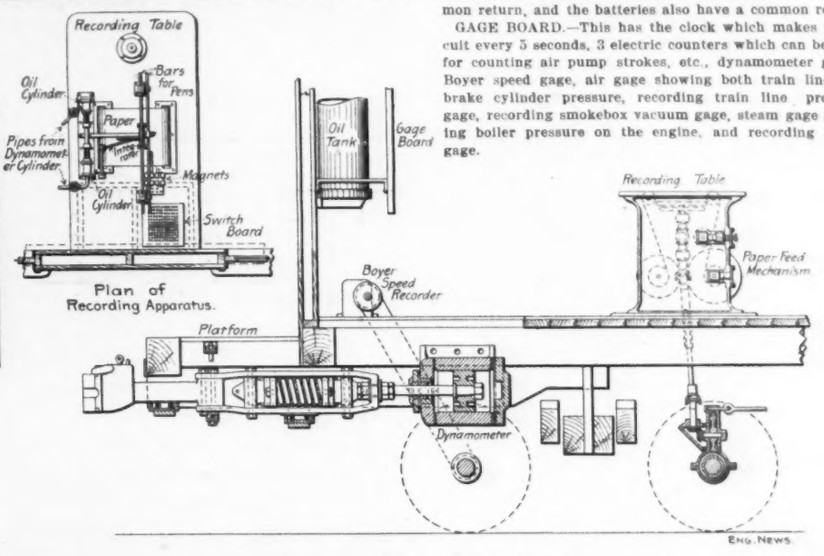
A, A, = Bars for Holding Pens.
B = Magnets.
C = Switchboard.
D = Integrator.
E, E, = Oil Cylinders.
F, F, = Pipes from Dynamometer Cylinder.

*Eng. News. 1900, II., 71; 1901, II., 28.

rect for difference produced by the head of oil. Pressures are now produced by means of the gage tester, starting with say 20 lbs. per sq. in. and using increments of 20 up to the desired limit of 200 or 300 lbs. per sq. in. each pressure the corresponding ordinate is obtained the same manner as in testing the datum line. Having these various ordinates corresponding to various pressures per sq. in., and knowing the area of the dynamometer piston and dynamometer piston rod, we figure the corresponding drawbar pull. From this we then plot a calibration chart showing ordinate in inches horizontally and the drawbar pull vertically. This calibration in practice takes about 10 or 15 minutes, and is made with everything in place ready for service. During a series of tests a number of calibrations are made, and the datum line tested before and after each trip.



Sectional End Elevation.



Sectional Side Elevation.

FIG. 3. FEED MECHANISM AND RECORDING APPARATUS.

In service, when the engine is pulling, the back end of the dynamometer is open to the oil tank through the check valve, described above, and also to the back end of the recorder; while the front end of the dynamometer is open only to the front end of the recorder. The oil head in the tank acting through the dynamometer produces pressure in the front end of the recorder, but it also acts directly on the back end of the recorder and the two thus neutralize each other. Any oil head in the tank, or for that matter, any excess pressure or vacuum that may occur in the back end of the dynamometer while engine is pulling, has no effect on the recorder, and only the pressure in the front end of the dynamometer due to the pull of the engine is recorded.

FEED OF PAPER.—The feeding mechanism, shown in Fig. 3, consists of a worm and gear on the axle under the recording table which drives a shaft running up into the car, which in turn drives some gearing, and motion is finally produced in a brass feed roll. Paper is passed by this brass cylinder and made to press against it by means of a rubber roll. As at present constructed, the paper may be fed at the rate of about one foot of paper to the mile of track or two feet to the mile. For most work we use the former feed, although for a great deal of train resistance work the latter feed is used, and sometimes it would be desirable to have still greater feed of paper.

MAGNETIC RECORDING PENS.—Besides a record of drawbar pull, we have also arranged to get records of distance, location, time, reverse lever positions, places where indicator cards were taken, integrator record showing area of dynamometer diagram, and at times other records. The recording pens consist of eight electro-magnets and four pens, each pen being connected with two of the electro-magnets and arranged so that one electro-magnet deflects the pen in one direction and the other in the opposite direction. A sample record is shown in Fig. 4. To locate mile posts, stations, etc., an observer is placed in the cupola, and as the car passes a mile post he pushes a button which actuates an electro-magnet and this in turn deflects a recording pen, making a notch in the record line. Time is recorded by means of a clock closing a circuit every five seconds, and this in turn notching the same line in the opposite direction. Reverse lever positions are recorded by an observer in the engine cab pressing a button an appropriate number of times; the places where indicator cards are taken are recorded in a similar manner by an observer on the front end of the engine pressing a button just before taking the card. The various wires running from the engine into the car are collected into one cable, and suitable terminals are placed in the car and on the end of the cable to allow of connecting or disconnecting quickly.

MECHANICAL INTEGRATOR.—This is a very important and useful adjunct which automatically records the area of the dynamometer diagram as it is produced. The integrator, Fig. 5, consists of a wheel 1½ ins. diameter, whose plane at zero ordinate is about at right angles to the line of motion of the paper, but as the drawbar ordinate increases, the plane of the wheel is rotated and the wheel thus revolves as the paper moves under it. The number of revolutions of the wheel is a function of the length of the paper passing under the wheel and the length of the ordinate; that is, it is a function of area of dynamometer diagram. The integrator wheel also has attached to its shaft a small commutator having 20 contacts on its circumference and each time a contact is made, it actuates one of the recording pens. The dimensions of the instrument are such that each contact or notch in the record line equals 2.243 sq. ins. of area of dynamometer diagram above integrator zero line. In practice it is usual to set the integrator so that the integrator zero line is somewhat below the drawbar zero line, and then determine what is the constant difference between the two lines, the integrator zero line, however, not being actually drawn. To determine the average ordinate of a given length of diagram, we count the number of integrator notches included in this length, multiply by 2.243, then divide by the length of the diagram, and finally subtract the constant, which then gives us the average ordinate of the dynamometer diagram. From the calibration chart, we find the corresponding drawbar pull. In the "Transactions of the American Society of Mechanical Engineers," Vol. 22, 1901, page 83, the author described the mechanical integrator which was used with our old dynamometer. The principle of the present integrator is somewhat different and was copied from one used by the Pennsylvania R. R.

SWITCHBOARD.—The various wires of the car come to terminals on one switchboard placed on the recording table. This switchboard will take care of 12 push buttons or places of making contact, also of 12 electro-magnets. At present we have seven independent lines where circuit can be made and 11 independent electro-magnets, eight of these are used for actuating pens and three of them for actuating counters. For batteries we have 30 ordinary ammonium-chloride wet batteries, arranged in three sets of 10 each. The batteries are arranged in multiple series, with two cells in each series, thus giving a pressure of about 2 volts. The various push button circuits have a common return, the various electro-magnets have a common return, and the batteries also have a common return.

GAGE BOARD.—This has the clock which makes a circuit every 5 seconds, 3 electric counters which can be used for counting air pump strokes, etc., dynamometer gages, Boyer speed gage, air gage showing both train line and brake cylinder pressure, recording train line pressure gage, recording smokebox vacuum gage, steam gage showing boiler pressure on the engine, and recording steam gage.

GAS ANALYSIS APPARATUS.—This is an Orsat apparatus as modified by A. Bement, and was obtained from him. A pipe extends into the smokebox of the locomotive, ordinarily just back of and below the exhaust nozzle, and runs from there back into the test car, a suction pump being placed in the car to draw the smokebox gases back through the apparatus. Care is taken to see that the pipe line is tight by closing a small pet cock just outside of the smokebox, producing a little vacuum in the pipe and then noting if this is sustained, by means of a column of water in a glass tube. The various absorbent solutions are potassium hydrate for absorbing carbon dioxide, pyrogallic acid for absorbing oxygen, and cuprous chloride for absorbing carbon monoxide.

LISTS OF TESTS.—The following is a list of the more important tests made with the car since first built, the tests made in 1901 being with the remodeled car. This list is not at all complete, but gives an idea of the various uses that have been made of the test car. The car was built in 1885 with twin spring dynamometer, and was remodeled in 1901 with a hydraulic dynamometer and gas analysis apparatus added.

1885. Tests made of tractive force of various engines.

1886 and 1887. Burlington brake tests made for Master Car Builders' Assoc., from Burlington, Ia., to Middletown, Ia.

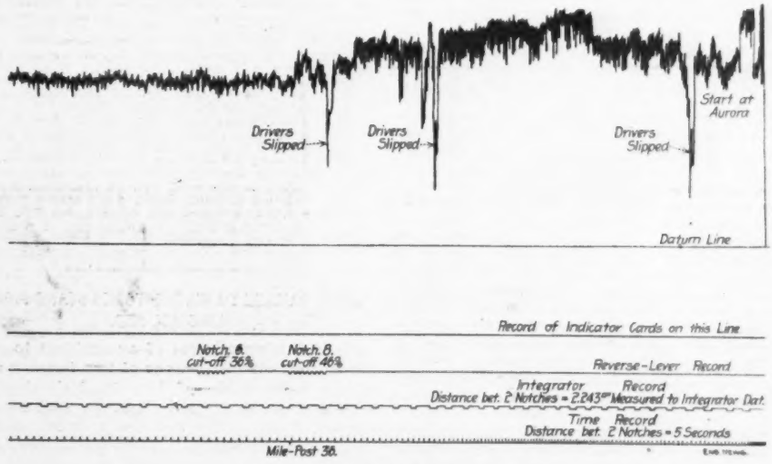


FIG. 4. DYNAMOMETER DIAGRAM.

1886. Relative tractive power with 53-in. and 57-in. wheel centers. Comparison of engines with 17-in. and 18-in. cylinders.

1887. Comparison of four engines in passenger service; coal, water, dynamometer records and indicator cards.

1891. Test of compound engine No. 324 and simple engine No. 75.

1892. Tests of six engines in passenger service, four simple and two compound; coal, water, indicator cards, and dynamometer records.
1894. Tests of five engines in freight service, three simple and two compound; coal, water, indicator cards, and dynamometer records.
1895. Car loaned to Denver & Rio Grande R. R. Rail washer tests, resistance of cars with sand on rail and sand washed off.
1897. Car loaned to Chicago & Northwestern Ry.
1899. Rail washer tests; resistance of cars with sand on rail and sand washed off.
1900. Train rating tests; Creston Division, C. B. & Q. Ry. Train resistance, as affected by length of train, empty and loaded cars. Tonnage rates equalized for length of train, Galesburg to Mendota. Passenger train resistance, variation with increase of speed; fast mail tests. Freight train resistance, side bearings and center plates lubricated and not lubricated. Narrow and wide fireboxes; gas analyses.
1901. Curve resistance tests at West Alton, Mo. Freight train resistance; side bearings and center plate lubricated and not lubricated. Compound and simple engines in freight and passenger service; cylinder and boiler performance, mechanical efficiency and gas analyses.

Finally, I wish to say that in remodeling our car, especial credit is due Mr. C. C. Higgins, my assistant, who made the necessary designs and drawings, and looked after the construction. My thanks are also due to a good many others who offered suggestions and helped in various ways.

BALL BEARING STANDARDS for large sluice and gate valves have been installed by several water-works plants. The balls are placed both above and below the screw nut collar in grooves formed in hardened steel rings. The lower bearings are double and the balls and rings rotate in an oil reservoir. The upper bearing is single. It takes the thrust when the valve is being closed, while the lower bearings take the opening thrust. These standards are made by the Coffin Valve Co., of Neponset, Mass.

BIDS FOR A WIRELESS TELEGRAPH SYSTEM for Alaska were opened in the office of Gen. A. W. Greely, Chief Signal Officer of the U. S. Army, on May 6. The following lines and respective distances of communication were specified: (1) Ft. Davis to some point on Stewart Island, about 90 nautical miles, or Ft. Davis to Ft. St. Michaels on St. Michael Island, about 108 miles; (2) Rampart to Winter House, on the Tanana River, about 136 miles, or preferably Fort Gibbon to some station on the Tanana River, about 155 miles. The successful bidder was required to demonstrate his ability to transmit messages legibly for two consecutive days over a distance of 60 miles, and to work his system satisfactorily for a period of from ten to twenty days, as might be required. Five bids were received, as follows:

The Marconi Wireless Telegraph Co. asked $9,919.66 and $11,005.12 respectively for equipping routes A and D, to be completed respectively by Sept. 1 and Oct. 1, 1902. They were prepared to guarantee a speed of transmission of 12 words per min. The bid further called for an aggregate royalty for the four stations of $1,000 annually after the first year, and in addition the amount of 50% of all receipts for other than government messages.

Foote, Pierson & Co., of New York, offered to furnish apparatus and equipment for four stations, delivered, for $28,800.

The American Wireless Telegraph & Telephone Co., Philadelphia, four or six sets of instruments, without poles or groundplates, $3,500 per set, to be completed by Oct. 1, 1902.

The De Forest Wireless Telegraph Co., New York, routes B and C, equipped complete, including masts and houses, $8,500 each, routes A and D, complete, $11,000 each. Speed of transmission, 20 to 25 words per min.; installation completed by Oct. 1, 1902.

Queen & Co., Philadelphia, representing the Fessenden system recently tested by the Weather Bureau, asked for the equipment of two stations: instruments, without masts or houses, $6,000; masts, houses, etc., complete, $7,000. This is for the shorter route; for the longer route the total price is $15,000. Delivery is to be in 60 days, and probable time of completion of installation, Oct. 1, 1902; a speed of 25 to 30 words per min. is guaranteed.

The five systems will be tested by a board of officers of the signal corps before any decision is made in regard to the bids.

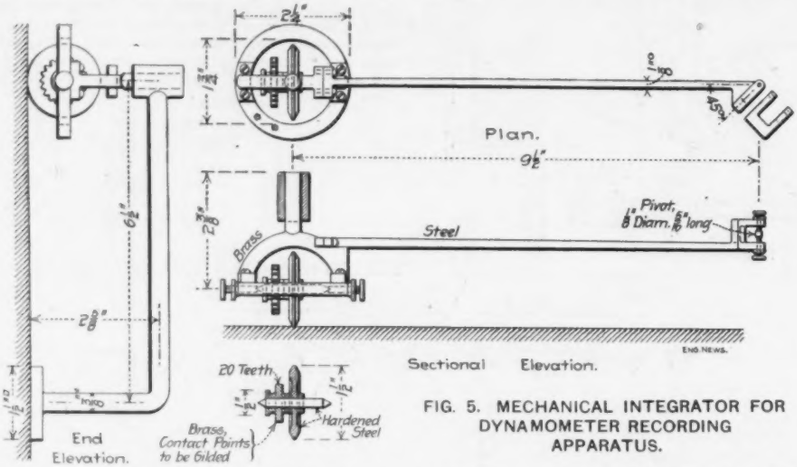


FIG. 5. MECHANICAL INTEGRATOR FOR DYNAMOMETER RECORDING APPARATUS.

A SEPTIC TANK INJUNCTION SUIT against the city of Plainfield, N. J., has proceeded as far as the filing of a bill of complaint in the U. S. Circuit Court, District of New Jersey, by the American Sewage Disposal Co., of Boston, of which Mr. John N. McClintock is president. The following abstract of the action has been sent to us by Mr. Andrew J. Gavett, City Surveyor of Plainfield:

The bill recites the granting of patent No. 559,522 on Sept. 23, 1895, to Amasa Glover, and its transfer through various parties to the orator in this case. Claims that "the application in the art of sewage disposal of the fact resting upon principles and laws which govern chemical and bacterial changes in organic and organized matter, sometimes known as 'septic action,' that sewage matter properly collected, confined and filtered and voided, or discharged, will undergo decomposition into gaseous and liquid elements or compounds was first thought of and said application first conceived and made in the disposal of sewage by said Amasa Glover before said application had been made by or known to any other person in this or any foreign country." That letters patent were granted to him on May 30, 1882 (No. 258,744). That Glover continued to experiment, had small experimental works built at Brockton, and that in rejecting his final plan for Brockton, the State Board of Health of Massachusetts either lost sight of, misconstrued or ignored the essential "septic action" of the Glover process.

There afterwards the said Glover still strenuously contined "his efforts to obtain an approval and use of his invention . . . . in or about 1895 reached the structural combination of said patent No. 559,522 as the proper, adequate and useful apparatus for carrying out his application of said principles."

The works at Brentwood, N. H., are referred to: "They were, as your orator is informed and believes, and therefore alleges, the first sewage disposal works built anywhere in the world with the intended purpose of utilizing the 'septic action,' so called." The bill claims that the company has expended large sums of money and devoted much time and effort to developing said invention, and states that "your orator is ready and intends to meet all demands for the general introduction of the same and believes that it will realize and receive large gains and profits therefrom if infringement by this and other defendants shall be prevented"; that the Plainfield works contain and embrace the invention described and patented in and by said letters patent No. 559,522, that the unlawful acts of defendant have the effect of inducing others to infringe. The bill asks "that the defendants may be decreed to account for and pay over the income or profits thus unlawfully derived from the violation of your orator's rights as aforesaid, and be restrained from any further violation of said rights, your orator prays that your honors may grant a writ of injunction" . . . . and an accounting of profits and damages. A preliminary injunction is also requested.

WIND DAMAGE TO WATER-WORKS STAND-PIPE AT LINCOLN, NEB.

The following account of an accident to a 25 × 100-ft. steel stand-pipe, one of two forming a part of the water-works of Lincoln, Neb., has been furnished to us by Mr. Chas. D. Biggerstaff, a student (1903) of the University of Nebraska:

Enclosed find photograph showing the nature of the accident which happened the South St. stand-pipe of the water-works of Lincoln, Neb., during the night of April 21-22, 1902. It was caused, as far as can be ascertained, by the wind.

Records of the U. S. Weather Bureau Office at the University Station, about 2¼ miles north from the stand-pipe, show the wind to have had an average velocity of 33 miles per hour from 3 p.m. Monday until midnight. Between midnight and 1 a.m., Tuesday, the wind [illegible] to a gale, blowing a maximum of 60 miles per ho[illegible] an average for five minutes of 57 miles.

The wind was blowing from the south, so the [illegible] as given by the weather bureau records would ans[illegible] well for the stand-pipe. The pipe is located [illegible] the wind having full sweep against it from any [illegible]

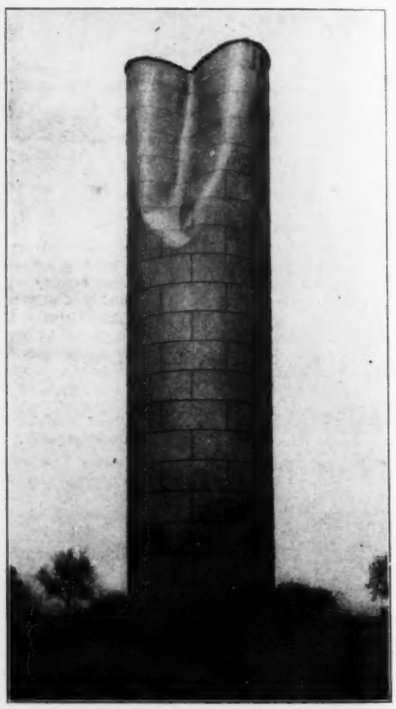
The stand-pipe was erected in 1893, by Mr. [illegible] Sholes, a contractor of Lincoln, after specifications [illegible] up by the city engineer. Owing to legal limitati[illegible] interference the city engineer was not allowed to [illegible] intend the construction, so any deviations from [illegible] and specifications are not to be charged to him. [illegible] water commissioner acted as superintendent of co[illegible] tion, in connection with the chairman of the Bo[illegible] Public Works. As to his engineering capabilities [illegible] correspondent knows nothing.

The stand-pipe rests on a concrete foundation of [illegible] strength for any load which might occur. The spe[illegible] tions called for the following thicknesses and weig[illegible] metal plate:

Section, ft. from bottom.	Thickness, in.	Weig[illegible] sq. f[illegible]
Bottom plate	¼	2[illegible]
1 to 5 ft.	⅜	3[illegible]
6 " 10 "	17/64	2[illegible]
11 " 20 "	9/32	2[illegible]
21 " 30 "	5/16	2[illegible]
31 " 40 "	11/64	2[illegible]
41 " 45 "	7/32	17.[illegible]
46 " 55 "	3/16	15.[illegible]
56 " 65 "	5/32	12.[illegible]
66 " 80 "	⅛	10.[illegible]
81 " 100 "	5/64	7.[illegible]

The other chief features of the specifications were as follows: Tensile strength to develop 60,000 lbs. per sq. in.; vertical seams double riveted and horizontal seams single riveted; bottom united to shell by a 6 × 6-in. steel angle, properly riveted to give maximum strength; top stiffening ring to be a 3½ × 3½-in. steel angle securely riveted in plate. Eight anchor rods, 1¾-in. diameter, securely anchored in the concrete foundation and passing through heavy lugs riveted to shell. Plates to be of such size that eight plates make a course of 25 ft. diameter and 20 courses make the height 100 ft.

Besides the dent, as shown in the view, the angle stiffening ring was broken in several places. This ring was in sections riveted on the outside of the shell. The joints were butt joints held by flat plates.



View Showing Effect of Wind on Stand-Pipe at Lincoln, Neb.

Two of the anchor rods on the south side were broken and the surfaces showed quite a crystalline fracture. Luckily the bolts broke in the threaded portion high enough so that the heavy batter washers could be removed and nuts replaced.

As to the accident, the water commissioner, who has charge of the system, said:

In regard to the crushing in of the pipe I would say it was caused by a small twister or cyclone. Although

exact knowledge of the amount of water in the pipe time can be obtained, yet I think there was at least The bolts that were broken failed, as you will un- and, from the stand-pipe tipping or rocking back and When I went out the next morning, I found all ther anchor bolts with their nuts up off the washers.

questions which naturally arise are: (1) Was the truction faulty around the top? (2) Was there any amount of water in the pipe? (3) Was there any- of the nature of a cyclone at the time of failure? last question invites the answer that no damage done to trees or buildings not more than 200 ft. north the pipe. That the wind force was excessive could shown by calculations on stability of the pipe, using the ifications for the shell as a basis. Question (2) would be answered by the above calculations. Question (1) ld only be answered by a thorough inspection by an ex- together with tests of material used.

HENRY MORTON.

In the death of Dr. Henry Morton, President of the Stevens Institute of Technology, the engineering profession suffers a great loss. Dr. Morton was the organizer of the Stevens Institute, under the provisions of the will of Edwin A. Stevens, in 1870. He was its president for 31 years, and was also its financial benefactor, contributing to it from his private means various sums at different times, amounting in the aggregate to $145,000. In connection with his office as president he gave instruction in physics and electricity to more than a thousand students, most of whom are now practicing mechanical and electrical engineers. The Stevens Institute was the first college in the world to be organized as a special school of mechanical engineering, and its curriculum as originally designed by Dr. Morton has been generally followed by all mechanical engineering schools since established.

Dr. Morton was the son of the Rev. Dr. Henry Jackson Morton, who was for 56 years rector of St. James's Protestant Episcopal Church in Philadelphia. He was born in New York city on Dec. 11, 1836. He graduated from the University of Pennsylvania in 1857. While in the university he devoted much time to the study of Egyptian hieroglyphics, and made a translation of the hieroglyphic text of the famous Rosetta Stone, the Greek and Demotic texts being translated by his two colleagues, and in 1858 he reproduced by drawing on stone the manuscript of the entire work, making a book of 172 pages, with upwards of 100 original illustrations in color.

On graduating from the university he entered the law office of Mr. George M. Wharton, in Philadelphia, and while a student there he was induced to give a course of lectures on chemistry and physics to the boys in the Episcopal academy. The lectures were so remarkably successful, attracting pupils from outside academies and the general public, that numerous offers of professorships came to him, and he was led to abandon the career of a lawyer for that of a teacher. In 1863 he was elected professor of chemistry in the Philadelphia Dental College, and in 1864 Secretary of the Franklin Institute and Editor of its "Journal."

In order to augment the usefulness and pecuniary resources of the Franklin Institute, Professor Morton delivered in the Academy of Music in 1865 a series of lectures on light, sound and other topics, which established his fame as a scientific lecturer. The auditorium, seating over 3,500 persons, was crowded at every lecture, and the optical, chemical and physical experiments performed were on a colossal scale, such as had never before been attempted.

In 1868 he was appointed professor of chemistry and physics in the University of Pennsylvania. In 1869 he organized and conducted a scientific expedition to Iowa to observe the total eclipse of the sun on Aug. 7 of that year.

In June, 1870, Professor Morton resigned the office of Resident Secretary of the Franklin Institute to accept the presidency of the Stevens Institute of Technology, the faculty of which he then proceeded to organize, and the Institute was opened for students the following year.

In a biographical notice published in 1892 appears the following:

> At the time when President Morton took charge of the Institute he formulated such a provisional working plan for the conduct of the future school as the needs and knowledge of the hour suggested. This plan was purposely left flexible as to its details, and, from that time to the present, friendly criticisms have been asked for from trustees and faculty, from alumni and student, from the engineering profession at home and abroad, and the results of those criticisms, after discussion and trial, have been incorporated, where approved, in many departments of the Institute. . . . While the Stevens Institute stood alone 20 years ago there are now a score of institutions where mechanical engineering is taught, but the Institute still holds its leading position. . . . With all of this past, with as much of this bright future as his years and strength allow, President Morton is and will be identified, the Institute is his *magnum opus* and will be his enduring monument.

In 1880 Dr. Morton gave $10,000 to the Institute for the improvement of its workshop. In 1888 he gave $10,000 towards the endowment of a chair of Engineering Practice, and four years later $20,000 more for the same subject. In 1901 he gave $50,000 for the endowment of a new chemical building, to be erected from funds subscribed by himself and the alumni in former years, and he also paid for the erection of a boiler house built in connection with the new Carnegie engineering laboratory.

During the past 31 years, in addition to his work as president of the Institute, and taking charge of classes in physics and electricity, Dr. Morton devoted a great deal of time to work as an expert in patent causes and other litigation, especially in chemical and electrical cases. In this

Henry Morton.

work he was in the foremost rank, and it brought him large fees. He also carried on many original investigations, notably in the chemistry of coal-tar derivatives and in fluorescence. In 1897 he received the honorary degree of Doctor of Laws from Princeton University, and the degree of Doctor of Science from the University of Pennsylvania. He was elected a member of the National Academy in 1873.

During the past year Dr. Morton was in rather poor health. On April 15 he underwent an operation for disease of the kidneys, from which he recovered, and he gained steadily for ten days, when a relapse ensued, and he sank slowly until his death on May 9. He leaves two sons, Henry S. and Quincy L. The former is a graduate of the Institute and a patent lawyer, and the latter a member of the Senior Class. Dr. Morton's wife died last September.

COMPUTING THE STRENGTH OF CONCRETE-STEEL BEAMS.

By Louis F. Brayton.*

The accompanying table for the moment of resistance of reinforced concrete is computed according to theory "B," presented by Professor Hatt in Engineering News of Feb. 27, 1902.

*638 No. Meridian St., Indianapolis, Ind.

The assumption there made was that the steel takes the entire tensile stress, while the compression is carried by the concrete alone. This seems to be a logical assumption, since a flaw or crack, which would render concrete worthless in tension would not necessarily take from its strength to resist compression.

The uncertainty of the value of concrete in compression as compared with the ultimate strength of steel warrants a greater factor of safety in the former, hence the accompanying table is computed with an ultimate strength of 2,800 lbs. per sq. in. and a factor of safety of four, i. e., 700 lbs. per sq in. as safe load on the concrete. Steel is allowed a unit stress of 16,000 lbs. per sq. in.

As in the article referred to,

b, b = depth and width respectively, of the rectangular section;
x = a fraction of the depth of section, and is the distance of the neutral axis from the compression side;
u = a fraction of the depth of section, and is the distance of the center of gravity of the reinforcement from the compression side, here assumed = 5/6;
p = ratio of steel to concrete;
F = area of concrete = b h;
F′ = area of steel = p F;
E_c = modulus of elasticity of concrete, and equal to 2,000,000;
E_s = modulus of elasticity of steel and equal to 30,000,000;
f = safe stress in steel, equal to 16,000 lbs.;
c = safe stress in concrete, equal to 700 lbs.

Then, as was shown,

$$\frac{2}{3} c x = p f; \qquad (1')$$

$$p \frac{E_s}{E_c} (u - x) = \frac{2}{3} x^2. \qquad (4')$$

Eliminating p between equations (1′) and (4′),

$$x = \frac{\frac{c}{f}\frac{E_s}{E_c} u}{\frac{c}{f}\frac{E_s}{E_c} + 1}, \qquad (5')$$

which value, multiplied by the total depth, gives the distance to the neutral axis from the compression side.

Substituting this value of x in (1′)

$$p = \frac{2}{3}\frac{c}{f} \frac{\frac{c}{f}\frac{E_s}{E_c} u}{\frac{c}{f}\frac{E_s}{E_c} + 1}, \qquad (6')$$

which, multiplied by the cross-sectional area of the concrete, gives the area of steel reinforcement required.

These values of x and p will be found very easy and convenient to remember.

Substituting the values assumed above,

$$x = \frac{1}{3} \quad \text{and} \quad p = \frac{1}{104},$$

for all practical purposes.

The moment of resistance of the section is obtained by substituting in the following formula which is obtained by taking moments about the center of gravity of the compression parabola which is 3/8 x h from the compression side,

$$M = F' h [f (u - \tfrac{3}{8} x)].$$

After assuming values for f, u and x, the quantity in the brackets becomes a constant, so that for the values here assumed,

$$M = 11{,}352\ F' b.$$

Since the steel required varies directly as the depth of section, and the moment of resistance varies directly as the square of the depth, having solved one section, any other, under the same assumptions, may be solved by proportion.

Properties of Concrete-Steel Beams.

Depth of section in ins.	Center of gravity of steel in inches from tension side.	Area of steel in sq. ins. per ft. width.	Moment of resistance in ft.-lbs. per ft. width.*
2	0.33	.23	438
3	0.50	.35	984
4	0.66	.46	1,749
5	0.83	.58	2,733
6	1.00	.69	3,935
8	1.33	.92	6,996
10	1.66	1.15	10,932
12	2.00	1.38	15,743
14	2.33	1.62	21,426
16	2.66	1.85	27,986
18	3.00	2.08	35,421
20	3.33	2.31	43,728
22	3.66	2.54	52,961
24	4.00	2.77	62,971

*Stress in steel, 16,000 lbs: in concrete, 700 lbs.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - - VICE-PRESIDENT.
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ALFRED E. KORNFELD, New York,
M. C. ROBBINS, Chicago,
S. B. READ, Boston.
} ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 322 means that subscription is paid to the 32d week (that is the issue of Aug. 7) of the year 1902; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

A very curious, and, to an American engineer, a surprising feature of the Berlin electric railway, described in this issue, is the very light track construction employed. American engineers have thoroughly learned the lesson of the value of heavy rails, particularly on roads operated by electric motive power. Yet here are these German engineers calmly building a high-speed electric railway for rapid transit service in Berlin, and using rails weighing only 51 lbs. per yard, with ties spaced 30 ins. apart on one portion of the line. On another portion, a still more astonishing construction is employed, viz., ties spaced *five feet* apart on centers with a rail 180 mm. (7 ins.) high and weighing 86 lbs. per yd. If this track maintains its line and surface under electric motor-car traffic, there must be something in German conditions very different from those which obtain in the United States.

So far as maintenence of line is concerned, conditions on the Berlin road are made worse by the very peculiar section of the rail. This has the web placed to one side of the center, so that the webs of two rails may lap at the joint, the heads and feet of the rail being halved to permit this. In this manner the German engineers responsible for the design of this road expect, according to their own accounts, to maintain a suspended joint with a clear distance of over 4 ft. between the ties on either side!

It might be possible to operate such a road with very light rolling stock moving at low speeds; but this road is to carry electric motor cars weighing 26 tons and 3-car trains are to run at speeds of 30 miles an hour at intervals of 2½ to 5 minutes.

We are wholly at a loss to account for the adoption of such a wide tie spacing on a road to carry such a traffic. The object apparently was to avoid the use of stringers and intermediate cross beams in the floor system; but the trifle saved in this way must have been much more than counterbalanced by the cost of the special rail section and the awkward and difficult rail joint. It might be surmised that the engineers were led to this mistake—for we cannot regard it as anything else—by a theoretical comparison of the wheel loads of electric cars and of locomotive driving wheels. There are surely electric railways enough in operation in Germany, however, to set them right on this point, even if they were entirely ignorant of American practice.

Whatever the explanation may be, the road is now completed and in operation, and experience will have to determine how long the ties and rails laid in the manner above described can continue in service.

The Pittsburg water purification project is as bady muddled just now as the city's water supply at its worst. The strangest part of the situation is that the present confusion is immediately due to the reform element which recently gained control of some branches of the city government. As many of our readers know, the city was on the point of awarding a contract for settling basins and slow sand filter beds, as described at length in Engineering News of Feb. 13, 1902, when an injunction was secured against contracting for any portion of the water supply improvements until estimates for the whole had been made. Unfortunately, the charter which contains the provision on which this ruling was based contains another provision which declares that in case bids for city work exceed the estimates the contract in question shall not be let. Any engineer will understand how farcical estimates become under such conditions, particularly when municipal reform is in the air. If the estimates are at all close there is danger that the bids will exceed them and thus have to be rejected; if they are high enough to guard against such a contingency, a popular outcry against extravagance may be expected, and there will be a tendency for bidders to raise their prices higher than they otherwise would. At Pittsburg, new estimates, covering the whole water supply improvements, have been submitted to councils. They are necessarily high, for the reason just stated, and they appear to be higher still because laymen are comparing them with the preliminary estimates of four years ago, when prices were much lower than at present. Add to these conditions the fact that the chief executive officers at Pittsburg are appointed by the governor of the state, under the well-named "ripper" bill, while a majority of the present city councils have just been elected as a popular revolt against ripper legislation and ring rule, and it is no wonder that the water purification project is in a muddled condition. To crown all, however, the city controller has refused to pay any more bills from the funds in hand for an improved water supply, except those incurred under previous contracts. This is interpreted to mean that the whole staff, with the possible exception of Messrs. Hazen and Knowles, engaged on final plans and estimates for the improved water supply, must be discharged. The alternative would be a special appropriation for carrying on the work, but this would have to come from the reform councils. Vague stories are abroad to the effect that the new councils will insist on mechanical filtration, or a gravity supply of naturally pure water, or at least that they will take up anew the whole subject of an improved water supply. Until these rumors are verified they need be given but little attention. Certainly, if the reformers at Pittsburg are worthy the name they will not ruthlessly sweep away the wheat with the chaff. The past rottenness of Pittsburg municipal government is proverbial, but the general plans for improving the water supply of Pittsburg were adopted by the filtration commission and the people at large on the recommendation of engineers and sanitarians whose personal integrity and professional reputation is held in the highest esteem throughout the whole country. If there has been unnecessary delay in working up the details of those plans and putting them under execution then there is all the more reason for pushing them forward from now on. The c[r]itical filtration experiments at Pittsburg, com[b]ined with the studies for a possible gravity supply [a]dopted a year or two and cost some $40,000. T[h]e like amount of time and money on a v[e]ry du-plication of the studies would be foo[l]ish. The people of Pittsburg should remember [t]hat their present impure water is costing them [m]any lives and hundreds of thousands of dolla[r]s yearly, and that municipal reformers are altog[e]ther too prone to sacrifice indiscriminately all [m]easures and measures connected with the previous [a]dminis-tration.

THE ROLL OF GREAT DISASTERS.

Many of the older readers of Engineering News may remember an editorial with the above title which appeared in this journal shortly after the Johnstown flood in 1889. It was from the pen of the late A. M. Wellington, and recounted in his interesting style some of the chief calamities which have visited the globe since the dawn of history.

At the present time, when attention is concentrated on the great disaster which fell upon the Windward Islands in the West Indies last week, it seems appropriate to again consider this subject.

The dispatches printed in the daily papers have made fairly clear the approximate extent of the West Indian calamity. The chief loss of life appears at present to have been in the city of St. Pierre, on the French island of Martinique, which was overwhelmed on May 8 by a shower of molten lava that set the whole city on fire and very likely raised the temperature of the air to a point sufficient to cause the speedy death of those who escaped fatal injury from other causes. The city was not buried beneath the falling particles thrown out by the volcano, as were the ancient cities of Herculaneum and Pompeii, for search parties have already made their way among its ruins. Indeed, from the accounts so far received, the actual amount of volcanic matter which descended on the doomed city may have been comparatively small.

It is a curious fact that our only measure of the magnitude of these great calamities is the number of human lives overwhelmed. Thus a physical disturbance of comparative insignificance which happens to encounter a city in its path goes down into history among the great calamities, while others of much greater physical magnitude are barely noticed and soon forgotten. For example, there are very likely a dozen or fifty tornadoes every season in the United States as severe as that which visited St. Louis in 1896; but unless the narrow track over which one of them passes happens to include some densely populated city, the destruction wrought is usually comparatively small.

Similarly with volcanic eruptions. Taking the globe as a whole, discharges of volcanic matter are quite frequent, and it is only when some of this destructive matter chances to encounter a city or populous town that the physical disturbance becomes a great calamity which attracts the world's attention.

While the only measure of great disasters is the number of human lives blotted out, it is noteworthy that the exact loss of life in most of them is seldom or never accurately known. This is true even in the most civilized regions. After the St. Louis tornado it was found that in many cases individuals or entire families living in shanties on the river front were swept with their dwellings into the river and carried away, leaving no trace behind. After the floods which overwhelmed Johnstown in 1889 and Galveston in 1900, only a rough approximation could be made of the total loss of life.

If this is the case in the center of the most civilized communities, how much more is it the case in the semi-civilized or barbarous regions, where the chief calamities by volcanic eruptions and earthquakes have occurred. Here population statistics are meager and unreliable, and means for the collection and transmission of news are most imperfect. At present we know that St. Pierre, with its population of something over 25,000, has been totally

destroyed. Reports also indicate a loss of life amounting to some hundreds on the British island of St. Vincent, a hundred miles to the south, where the Soufriere volcano has also been in eruption. What has happened to the scattered dwellers in the country and the small villages in the northern part of the island of Martinique can only be conjectured at present. Very likely, when the total estimates are made up, it will be found that the loss at St. Pierre will be fully doubled, although on the other hand, it may be that the effects of the eruption have been less severe in the districts to the northward of Mt. Pelee.

Of all the calamities which menace mankind, none are so terrifying and awe-inspiring as the eruption of a volcano. None other so vividly impresses the mind with the magnitude of the elemental forces resident beneath the solid crust of the globe, in comparison with which man and all his works are puny indeed. Yet the actual losses of life by volcanic eruptions appear to have been small in comparison with the losses due to that other manifestation of the forces locked up in the earth's interior—the earthquake.

It is easy to see the reason for this. The effect of volcanic eruptions is confined usually to the immediate vicinity of the cleft in the earth's crust from which the interior matter is thrown forth. In the case of the present eruption, for example, St. Pierre, within five miles of the active crater, was destroyed. Fort de France, ten miles farther away, was uninjured. The earth's tremor, on the other hand, may extend for hundreds or thousands of miles. The actual number of volcanic craters on the entire globe is only a few hundred, and of these many are located in remote and sparsely inhabited regions. Earthquake shocks of considerable severity have occurred over a large part of the globe.

Of the disasters due to volcanic eruption, that of Pompeii is of course of greatest historical fame; but this is partly due to the fact that it occurred so close to the center of the world's then existing civilization. Very likely if the history of barbaric lands were recorded, it would be found that some of the centers of volcanic activity in the East Indies, in Japan, or in the Sandwich Islands have in times past claimed a greater number of victims than did Vesuvius at the destruction of Pompeii.

Among the most notable earthquakes, that of Lisbon is doubtless the most famous for a similar reason to that which has made Pompeii so celebrated. But the total loss of life in the Lisbon disaster (given by Mulhall at 35,000) has been several times exceeded in the past two centuries. In 1703 no less than 190,000 lives are said to have been lost at Yeddo, Japan, and in 1731 Pekin was visited by earthquake shocks which cost 95,000 lives. At Cairo in 1754, a year before the destruction of Lisbon, 40,000 lives were lost in an earthquake, and almost the same number were lost at Quito, in South America, in 1797. No longer ago than 1880 an earthquake in Manila cost 3,000 lives. The very recent earthquake at Shemakha in the Transcaucasus, in which 3,000 to 5,000 lives were lost, was described in our issue of April 24. Central America is a seat of almost continual seismal activity. In 1733, Guatemala experienced an earthquake which is said to have cost 33,000 lives, and only recently (on April 18) earthquake shocks are reported to have caused many deaths there.

It is of interest to note that in the disasters due to earthquake, most of the deaths usually occur from secondary causes. People are killed in earthquakes chiefly by the fall of buildings and other structures, and also by the tidal wave which is a most frequent accompaniment of earthquake shocks. In fact, in some cases such waves, due doubtless to an earth tremor beneath the sea, have swept upon a coast when no earth tremor had been felt at all. Everywhere man looks upon the ocean's level as only less fixed and unchangeable than the land itself. Just beyond the reach of its highest tides he builds homes and cities with supreme confidence in their safety. But the earth shock beneath the ocean bed often sets a wave in motion on the surface, like the ripple which a jar will start upon the surface of a filled cup, and it sweeps on the shore, carrying everything before it.

In the old time physics, matter was classified in the four elements of earth, air, fire and water. The volcano and the earthquakes may be said to represent activities of the first element; tornadoes the second; conflagrations the third, and floods the fourth. These last far exceed in magnitude all the other great disasters which history records. Indeed, it is altogether probable that the loss of life in floods since history began, exceeds the combined losses from all the other calamities named above. The greatest and most disastrous floods have been those from the ocean, of which the most recent example is the destruction of Galveston only two years ago, when some 12,000 lives were lost. Two other severe inundations of the South Atlantic coast have occurred during the past half dozen years, in each case accompanied by the loss of many lives among the dwellers on low-lying coast islands.

Of all the lands on which the ocean has wreaked its fury, Holland has suffered the worst, through the breaching of the dykes which shut out the ocean from great tracts lying below the ordinary sea level. The greatest of these disasters, as recorded in the paper referred to above, was in 1530, when no less than 400,000 lives are said to have been lost. A century later, in 1646, 110,000 persons met death in another great inrush of the ocean.

Compared with these, the loss of life in flooded river valleys is insignificant. Here, except in such rare instances as that at Johnstown, where the flood caused by the breaking of a dam rushed down a narrow valley before warning could be given, most persons in the flood's pathway are able to flee to higher ground. The only great disasters from river floods which can compare with those from floods of the ocean have occurred on the flat delta plains at the mouth of great rivers, where the land was crowded with a dense population. The most notable example of this is the Yellow River of China, by whose floods, in 1642, 300,000 lives are said to have been sacrificed, while 200,000 are believed to have been perished during a similar inundation only 15 years ago. In India, the Ganges rose in a similar flood in 1876, claiming some 200,000 victims.

On our own Mississippi, the loss of life in its frequent floods have been comparatively slight, due to the widely different topographical conditions. The so-called delta, from Cairo to New Orleans, is really an alluvial valley with comparatively steep slope, and plenty of opportunity for refuge in case of floods. The true delta plain below New Orleans is practically uninhabited.

Compared with these great calamities, those due to the failure of the works of man seem trifling indeed. It is by their number and frequency and the fact that they are, to a greater or less extent preventable, that they deserve and receive so much larger share of attention.

Finally, there are two classes of great disasters which have each cost more lives in the aggregate by far than any of the elemental disturbances—the so-called "acts of God." These are great pestilences and great battles, the first due to man's ignorance, the second to the rein which he gives to his more primitive and savage instincts. Modern civilization is fast proving itself able to cope with the causes of each of these great calamities, and future historians will have fewer of them to record upon the roll of great disasters.

LETTERS TO THE EDITOR.

Moving Load Shears in Trusses with Parallel Chords.

Sir: In your number for April 10, 1902, I noticed a communication under the above caption.

For those of your readers who are interested in this subject I would like to add that methods similar to the one there described can be found in the following: Merriman's "Roofs and Bridges, Part I., Stresses," pp. 89 and 90 of the 1890 edition; Du Bois' "Stresses in Framed Structures," p. 83; Transactions Am. Soc. C. E., 1899, paper by L. M. Hoskins on "General Criterion for Position of Loads Causing Maximum Stress in any Member of a Bridge Truss." This last-mentioned paper by Prof. Hoskins is the best thus far presented to the profession.

C. M. Chadbourne.

Stanford University, California, April 28, 1902.

Utilizing the Heat of Slag for Developing Power.

Sir: The article by Mr. A. W. Clapp in your issue of May 8, in which it is stated that Mr. Mitchell claims to be able to develop 8,000 HP. from the waste heat of 600 tons of slag in 24 hours suggests a calculation to ascertain the possibility of such a result.

Nothing is said about the nature of the apparatus, but it is not likely that the slag from smelting furnaces can be delivered into any sort of apparatus at a higher temperature than 2,000° F., or that it will be practicable to discharge it at a lower temperature than 200° F. This leaves 1,800° as the loss of heat by the slag. The specific heat of slag is about 0.20, and $1,800 \times 0.2 = 360$ heat units as the quantity of heat that may be recovered from it per pound. Taking 600 tons per day, or 25 tons per hour, = 50,000 lbs. and multiplying by 360 gives 18,000,000 heat units per hour, equal to 1,800 lbs. of coal of an available heating value of 10,000 B. T. U. per lb. At 3 lbs. of coal per HP. per hour this equals 600 HP. Where does Mr. Mitchell get his data for figuring 8,000 HP.?

Very truly yours, "Thermal Unit."

New York, N. Y., May 9, 1902.

The Relative Cost of Macadam Roads at Port Huron, Mich., and Hudson, N. Y.

Sir: I noted in Engineering News of March 13 that Mr. Bishop took exception to my method of comparing the cost of macadam roads built at Port Huron, Mich., with those at Hudson, N. Y.; but as Mr. Bishop admitted that the method of hauling and distributing the stone with steam roller and spreading wagons was a good one, cheaper than the ordinary methods and better for the road, I did not think best to reply at that time, those being the only points of advantage claimed for steam hauling.

It can hardly be expected that roads could be built as cheaply at Port Huron, Mich., as at Hudson, N. Y., on account of the much higher first cost of the stone at Port Huron. Here, cobble stones were used, costing $6 per cord before crushing, and rather more than $1.00 per cu. yd. after the crushing cost was added.

Again, reducing the surface yards to compare with the Hudson roads (using the same factor as formerly for reasons given below), the crushed stone at Port Huron cost 35.55 cts. per sq. yd., instead of 12.75 cts. per sq. yd., the cost given for Hudson streets; this makes the material in the Port Huron roads cost 22.8 cts. per sq. yd. more than the material in the Hudson roads. If this difference is added to the cost of the Hudson roads they would have cost 64.55 cts. per sq. yd. as compared with a little over 51 cts. per sq. yd. at Port Huron, which difference, in part at least, lies in the difference between the two methods of delivering the materials to the roads. To be sure, a proper allowance should be made for the longer haul at Hudson and some other items pointed out by Mr. Bishop.

Again, in Engineering News of April 17 Mr. Gillette objects to my method of comparing results, which he admits is similar to that used by Byrne and other authorities. Without going into controversy as to the exact factor that should be used, I wish to point out that the factor used by me was fair for this particular comparison. In Engineering News of Jan. 9, Mr. Bishop states that 3-10 of a ton of stone was used for each surface yard of street. I allowed 25% for compacting and loss of finer material in the voids of the coarser, thus figuring that each 4.5 sq. yds. of street represented 1 cu. yd. of crushed rock. It will be noted that the weight of 4½ sq. yds. is 2,700 lbs., probably a little less than the weight of a cubic yard of the crushed stone used by Mr. Bishop, thus showing that if any error exists it tends to make my method of comparison more than fair to Mr. Bishop and the Hudson streets. Yours truly, F. F. Rogers, C. E.

Port Huron, Mich., May 5, 1902.

Amendments to the Safety Appliance Act.

Sir: My attention has been recently called to a paragraph which appeared in your journal of April 3, in which you refer to a bill now pending in Congress that designs amendments to certain sections of the Safety Appliance act. Your assumption that this bill will never become a law, adding that it should not be enacted, is no doubt predicated upon the idea that the united opposition of the railways to its passage will be effective in preventing it.

If the railways had adopted a device that conformed to the provisions of these amendments, or if the railways through their proper organization, the American Railway Association, should take steps to eliminate the defective couplers which are responsible for the terrible record of accidents that is annually forcing itself upon the attention of the public, there would be no occasion for the passage of these amendments, and they certainly would never have been suggested.

You state in the paragraph referred to that "automatic hose couplings have not reached such a state of perfection, so far as we are aware, that their compulsory use will be justified." I will ask the "News" what steps have the railways taken to ascertain whether or not a perfect automatic air-brake coupler does exist?

I would also ask, what have the railways done toward

adopting couplers of the necessary flexibility, so that they would couple on any practical curve? It is because the railroads have been and are completely ignoring devices of the above nature or kind, and which alone can secure the essentials of safety aimed at in the Safety Appliance act that has forced the question upon the attention of the Railway Commissioners of the several States and upon Congress.

As Chairman of the Committee on Safety Appliances (of the Association of State Railway Commissioners), in which capacity I have acted for the past two years, I have made a careful investigation of the conditions which now prevail with regard to the general car equipment of the country, and find that it is far more dangerous for trainmen to perform the duties required of them than it was under the link and pin regime.

This fact is patent to the most casual observer, and is borne out by the Interstate Commerce Commission's Annual Report, which for the past seven years has shown a steady increase of accidents each year over the previous one, until the last record, horrible to relate, shows 5,000 more than that of any previous year, and 11,474 more than it was in 1893. I am not in a position to say that the railroads could have adopted a better or safer coupling device (at the time they acted upon this matter) than the one in general use; but I do say, and it is a fact which no one will deny—that the conditions and requirements of service at the present time in railroad operation are such that the inherent limitations of the couplers in general use are so manifest, so matter of fact, that their discontinuance is practically conceded, by the railways, to be inevitable sooner or later.

It is also conceded that a device for coupling the air-brake pipes automatically and simultaneously with the drawhead is absolutely necessary for securing greater dispatch and economy of service in the manipulation of freight cars.

Wherein, then, will the passage of the proposed amendments prove a detriment to the railroads, even from a commercial or economic point of view?

Contrary to the opinion expressed by Engineering News, I believe that the proposed amendments to the Safety Appliance act now pending in the House of Representatives will become a law before the adjournment of the fifty-seventh Congress.

Would it not be well for the railways, under the auspices of the American Railway Association, to appoint a committee which shall arrange for a time and place to test all couplers which shall in the future be offered for service, and include in such arrangements a curved section of track having a radius not greater than 100 ft., and also to include in such test all automatic air-brake couplers that may be offered. Then upon the report of said committee, pass resolutions forbidding the use of all couplers which had failed to stand the proposed test, in equipping new cars or in replacing broken and worn out couplers. "The News" will bear in mind that two cars 50 ft. long, standing on a curve of the proposed radius, are at an angle of less than 30°, and it is not an uncommon thing to see cars standing at this angle in any of the freight yards of the country.

It goes without saying that when all the cars of the country are equipped with couplers that comply with these provisions, not only will the record of accidents to employees be reduced to one-third of the number shown in the last annual report, but it will result in the saving of millions of dollars yearly, in the prevention of wrecks and accidents and in securing far greater dispatch by eliminating the tediousness and consequent delay in making up trains, which characterizes the present regime.

T. J. Hennessey,
Chairman of Committee on Safety Appliances, and of the Railway Commission of Missouri.

St. Louis, Mo., May 2, 1902.

(We will preface our reply to the above questions by saying that Engineering News favored the enactment of the present Safety Appliance law, and would favor additional legislation for the reduction of accidents in the railway train service if convinced that such legislation would really accomplish the end sought. Our comment on the bill in question was made because we saw no real gain to the railway employees in it.

So far as the automatic coupling for air-brake hose is concerned, can our correspondent show any real gain to the safety of trainmen in its use? We believe the railway employees who are most familiar with air-brake work have never looked with favor on devices of this sort. The coupling up of the hose is not particularly dangerous, and any complicated automatic connection might easily lead to air-brake failures and defects, which would cost many more lives and limbs than the automatic coupling would save. Automatic hose couplings have been exhibited at the railway mechanical conventions and have received careful examination, we are sure, from railway mechanical officers. If a "perfect" one has yet appeared, we are not aware of the fact.

So far as car couplers are concerned, we agree with our correspondent that the railways have not moved as fast as they ought in remedying the difficulties in the coupler situation. But lack of flexibility is only one of these difficulties, and it is far from being the one which is causing the most accidents to railway trainmen. Why, then, should legislation on this particular point be so strenuously urged? If our correspondent will refer to the reports of the Master Car Builders' Association, he will find that in the original tests conducted by that association in 1885 the couplings were all tested on a curve of 20° 20′ (282 ft. radius). It has never been shown, so far as we are aware, that the M. C. B. type of coupling, properly made and properly applied, cannot meet this requirement. Our correspondent thinks that couplings ought to work on a curve of 100 ft. radius; but how does he know that such a requirement would not be detrimental instead of beneficial to the safety of the yardmen and trainmen? There are very few curves, even in yards, sharper than 20°, especially on railways where heavy traffic is handled. It might easily be that a coupler which would operate on a curve of only 100 ft. radius would prove unreliable and likely to become disconnected while trains are running and thus cause accidents instead of preventing them.

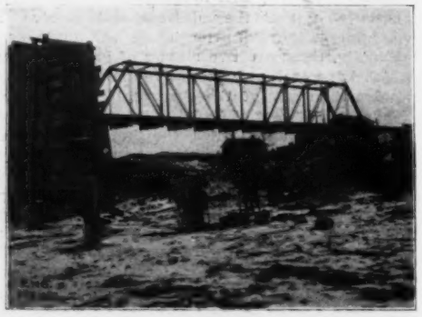
We said in an editorial discussion of this subject in our issue of Jan. 30 that the M. C. B. type of coupler is undoubtedly here to stay, and we still hold to that opinion, notwithstanding our correspondent's assertion that "the discontinuance of the couplers in general use is practically conceded by the railways to be inevitable."

Finally, if our correspondent is not fully convinced of the soundness of our position, we advise him to turn to the "Accident Bulletin" for July, August and September last, just issued by the Interstate Commerce Commission. He will there find statistics which show, as interpreted by the statistician, that the automatic couplers now in use have reduced by about one-half the casualties from the work of coupling and uncoupling cars. He will further find that among 21 separate causes of accidents enumerated in this work there is no record whatever of casualties occurring in the coupling of air-brake hose. Finally, he will find nothing whatever to show that lack of flexibility in the car couplings is a cause of casualties in their use.—Ed.)

Notes and Queries.

"Z." wishes to know whether concrete mixed with sea-water (not fresh water with salt added) gives as good results when immersed in sea-water, as if mixed with clean fresh water.

In the letter of Mr. W. H. Kutz, published in our last issue, information was asked as to the probable cause of movement in concrete piers after erection. We reproduce



Concrete Pier Under Construction for New Plate Girder Bridge over North Platte River, Fort Steele, Wyo., Union Pacific R. R.

herewith a photograph of one of the piers referred to while under construction. It shows the general type of framing used for the molds; but sheds little light, so far as we can see, upon the causes of the movements described by Mr. Kutz.

NOTES FROM THE ENGINEERING SCHOOLS.

UNIVERSITY OF WISCONSIN.—The authorities of this university announce the second session or year of the Summer School for Apprentices and Artisans; the session lasting from June 30 to Aug. 30. For a detailed description of the work done, fees, etc., send for Bulletin No. 4[illegible] Prof. J. B. Johnson, Dean of the College of Engineering, Madison, Wisconsin.

LEHIGH UNIVERSITY.—The new register of this university shows the attendance of [illegible] students, with 49 in the teaching staff. The list of graduates includes 1,203 names, covering [illegible] years of its existence.

PURDUE UNIVERSITY.—A temporary building is now in process of erection for the reception of historic locomotives now belonging to the university. The building is 60 × 64 ft. and will contain four tracks. The locomotives include the "James Tolmen," of English design; the P. C. C. engine No. 173, or the Hayes 10-wheel "[illegible]" and a 16 × 24-in. American type engine from the Chicago & Northwestern R. R. The university much desires to add an inside-connected engine to this collection.

NEW YORK UNIVERSITY.—A notable amendment of the rules for students in the Graduate School is the establishment of half courses. This new rule fixes a fee of $15 for the year, and includes all courses which demand attendance for not more than one hour per week throughout the year. Certain elementary courses are included though they demand two hours per week. Besides the literary and classical courses, the graduate school includes departments of mathematics, physics, chemistry, geology and physiology.

UNIVERSITY OF ILLINOIS.—A pamphlet of 32 pages has been issued, describing the new courses of training for business, which are designed to give a general foundation training for commercial business, railway service, banking, journalism, insurance, etc. The first part of the course is common to all, but the rest of the work is specially adapted to the particular purpose of the student. The courses are not technical in character, but at the same time they include the principles of power generation and transmission, which enter so largely into all branches of modern business and commerce.

A DIVING-BELL PONTOON.

For the improvement of the River Elbe a new type of boat fitted with a diving-bell is now being built in Germany, and is described as follows in the "Zeitschrift für Bauwesen."

This boat is built entirely of steel, and is 98.4 ft. long by 24.6 ft. wide, and it draws 2½ ft. of water. The diving-bell is located in an "overhang" on the starboard side, and is balanced by a similar overhang on the other side, carrying 15 cu. m. of water ballast. The first overhang is exactly opposite the middle line of the length of the pontoon. The diving-bell includes a central well, 6.56 ft. square, and two boat-shaped ends to diminish the resistance to the current. The working-chamber at the bottom is 6.56 ft. wide and 16.4 ft. long, and is lighted by incandescent electric lamps. Above this chamber the elongated ends form reservoirs for the water-ballast used in sinking the bell. In the roof and in the sides are openings, closed by rolling doors, for the use of the workmen.

This diving-bell is handled by a 50-HP. engine; and it is lowered or raised by means of screws and hoisting chains, which permit a speed of ascent or descent of 8.2 ft. per minute. The normal vertical movement is 9.2 ft.; but this may be increased at will.

As before mentioned, the bell is counter-balanced by 15 cu. m. of water-ballast located on an overhang on the port side. And to automatically maintain equilibrium the water-ballast in the reservoirs on the opposite side and that in the top of the bell are united by pipes connected by leather hose. One set of reservoirs is filled as the other is emptied.

On the pontoon is a centrifugal pump having a capacity at 550 revolutions of 2.2 cu. yds. per minute, lifted 16.40 ft. An air-pump on the pontoon sends, by a flexible hose, about 115 cu. ft. of fresh air per minute to the working-chamber of the diving-bell, under 0.5 atmosphere. Another engine and dynamo produce the necessary electric light.

ZINC-CREOSOTE FOR TIE PRESERVATION is being [illegible] for the first time in this country at the works of the [illegible]ko Tie Preserving Co., at Mount Vernon, Ill. This [illegible]s has been in use in Europe for several years. Mr. [illegible]e Chanute, M. Am. Soc. C. E., who is President of [illegible]bove company, visited Europe a few years ago for [illegible]rpose of investigating foreign practice and experi- [illegible]n timber preservation, and he became much im- [illegible]d with the results obtained by this process. He obtained the necessary formulas for the preservative solutions, but it was found impossible to obtain the proper quality of creosote in this country, and a supply has therefore been imported. The process was described by Mr. Chanute in a paper on "Preservative Treatment of Timber," read before the Western Society of Engineers, and published in our issue of Aug. 2, 1900, with a copy of the specifications for the process as used on the Prussian State Railways. In the report of the committee on ties, which was presented at the convention of the American Railway Engineering & Maintenance of Way Association (Eng. News, March 20, 1902), it was stated that the French State Railways estimated that ties treated by the zinc-creosote process would have a life 25% longer than that of ties treated only by the zinc-chloride process.

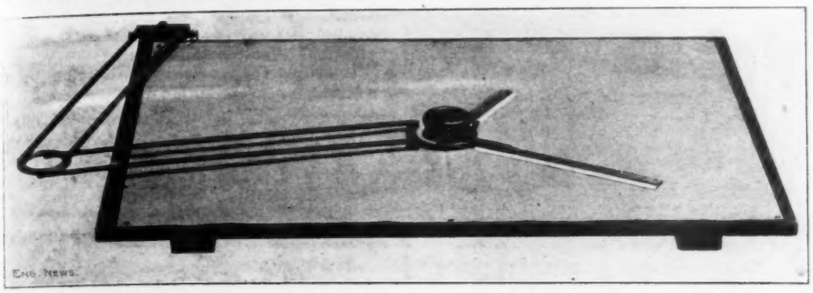


FIG. 1. THE UNIVERSAL DRAFTING MACHINE IN PLACE ON A DRAWING BOARD.

THE WORLD'S OUTPUT OF ZINC in 1901, according to statistics collected by Henry R. Merton & Co., of London, was as follows:

	1901. Tons.
Rhineland (Belgium and Holland)	199,285
Silesia	106,385
Great Britain	29,190
France and Spain	27,265
Austria and Italy	7,700
Poland	5,935
	375,760
United States	122,830
World's output	498,590

MANUFACTURERS' MATERIALS now form 49.13% of the importations of the United States, says the U. S. Bureau of Statistics. In value, for the month of March, they amounted to $41,381,755 out of a total of $84,230,559; for the nine months ending with March, they were $310,792,429 out of a total of $678,698,016, or about 46%. In 1890, this class of imports amounted to 34% of the total. The principal items of this import, in the order of importance, are hides and skins, chemicals, raw silk, fibers, copper, india rubber, wood, tin in pigs, raw wool and raw cotton.

THE WIRE ROD AND WIRE NAIL PRODUCTION for 1901 is reported upon by the American Iron & Steel Association. Iron and steel wire rods amounted to 1,365,934 gross tons, an excess of 61% over 1900. Of this product only 475 tons were iron. The output of steel wire nails amounted to 9,803,822 kegs of 100 lbs. each, an excess of 35% over the output of 1900. In 1895 this product amounted to 5,841,403 kegs. In 1901, 61 works manufactured steel wire nails.

AN ELECTRICAL CONTINUOUS SPIRAL STAIRWAY has been erected at Earl's Court, London, by the Reno Electric Stairway and Conveyor Co., of London. While the purpose of this stairway is to introduce the device to the public, it also carries its passengers on an illustrated trip through the Pyrenees. The whole is encased in a tower 101 ft. high by 80 ft. in diameter, and the length of the moving way is 386 ft. It is the familiar endless chain of steps and a moving hand-rail, arranged in a spiral; at the slow speed adopted its normal carrying capacity is 1,800 persons per hour, though this speed can easily be doubled, and for commercial or elevated railway purposes the inventor claims a capacity of 60,000 persons in a 10-hour day.

AN OFFICIAL STANDARD OF LENGTH for Chicago has been recommended by Mr. S. S. Greeley, the veteran surveyor. The subject was brought up by him at the April meeting of the Western Society of Engineers, and in the course of his remarks he stated that great discrepancies in measurements, distances and property lines exist as a result of the fact that the city has no standard measure of length. A resolution was passed to the effect that it is important that the city and county should possess proper mural or bench standards of length (officially adopted by the respective legislative bodies), with which engineers, surveyors, architects and others may compare their instruments of measurement. The resolution also expressed the opinion that the laws and ordinances relating to weights and measures should be obeyed and enforced by the county and city officers. A committee of five members was appointed by the President to consider the subject, to determine the proper shape, size, graduation and location of the proposed standard, and to ascertain where it can best be obtained. Other scientific bodies will be asked to co-operate in this movement, and the report will be submitted to the city and county officers.

FOR PROTECTING METALLIC TUBES against the corroding action of liquids M. Bergier, of France, proposes the following composition, as reported by U. S. Consul T. Haynes, of Rouen:

	Lbs.
Dry sand	220.4
Potash or soda	182.9
Nitrate of potash	4.4
Minium	.55
Pulverized marble	11
Dichromate	.22
Red oxide of copper	.11
Regulus of antimony	.11

These substances are vitrified, blown into cylindrical form and then introduced into the tube, the latter being brought to a white heat. The blowing in continued until the composition adheres to the metal. It is claimed that the composition expands and contracts in the same ratio as the metal.

THE TIMBER MARKET IN CHINA is discussed by U. S. Consul H. B. Miller, of Niuchwang. He points out that timber is exceedingly scarce for 1,000 miles up the valley of the Yangtze, and north of this stream there is no timber until the Manchuria-Korea boundary is reached. The present timber supply comes largely from Korea—fir and soft pine logs. Japan furnishes railway ties of a kind of oak from Hokkaido, the northern island; and the Island of Sakhalin, the Russian penal colony, has splendid forests of fir and pine. The teak wood so much used for furniture, etc., comes from the Philippines. Mr. Miller says that enormous quantities of timber are used in China for coffins, boats on the rivers and canals and for wooden tubs and buckets. He thinks there is an extensive market for Oregon pine, and for small and cheap sawmills. He can only locate two sawmills in China, both small circular-saw affairs, cutting about 2,000 ft. B. M. per day.

A LIST OF GOVERNMENT PUBLICATIONS on irrigation has been issued by the Superintendent of Documents, Union Building, Washington, D. C. This list covers all publications that are for sale at the prices affixed.

AMERICAN FARM PRODUCTS to the value of $952,000,000 were exported to foreign countries in 1901; this is over $100,000,000 in excess of 1900. In 1901 we imported products of this class to the value of $392,000,000, or $28,000,000 less than in 1900.

THE POSTPONEMENT OF THE ST. LOUIS EXPOSITION to 1904, has virtually been agreed upon by the officials of the exposition. The reason given is a lack of time to secure all the exhibits promised.

THE HISTORY OF THE N. W. BOUNDARY OF TEXAS is given in Bulletin 194 of the U. S. Geological Survey. This history commences in 1835, when Texas declared herself independent of Mexico. The boundary mentioned was first surveyed in 1859-60. The bulletin goes into the full detail of that and all later surveys.

DEVILS LAKE, IN NORTH DAKOTA, is gradually drying up, says the U. S. Geological Survey. This lake is glacial in original formation and it once had an outlet south into the Sheyenne River. But the lake long ago sunk below the level of the still well-defined outlet channel, and is now without an outlet and is slowly drying up. An interesting fact is that within the memory of living men the lake has changed from fresh to salt water, and the fish, abundant in 1888, are fast disappearing. The survey has established bench marks near the lake, and is making careful records of the fluctuations of level.

A LABOR-SAVING TOOL FOR THE DRAFTING ROOM.*

From time immemorial, as the phrase goes, the T-square and triangle or the double triangles have been the chief instruments used by the mechanical draftsman in the drawing of horizontal lines, vertical lines and lines parallel. About the only innovation has been the introduction recently, as a substitute for the T-square, of the ruler controlled by cords which pass over pulleys so that it remains in a horizontal position as it is moved up and down the drawing board.

We illustrate herewith a tool that appears to us to mark a long step in advance in the way of mechanical aids to the draftsman's work. It is a simple system of link-work secured to the upper left-hand corner of the drawing board which displaces T-squares, triangles, protractors and scales, and gives the draftsman the results obtained by all these separate instruments in a single tool.

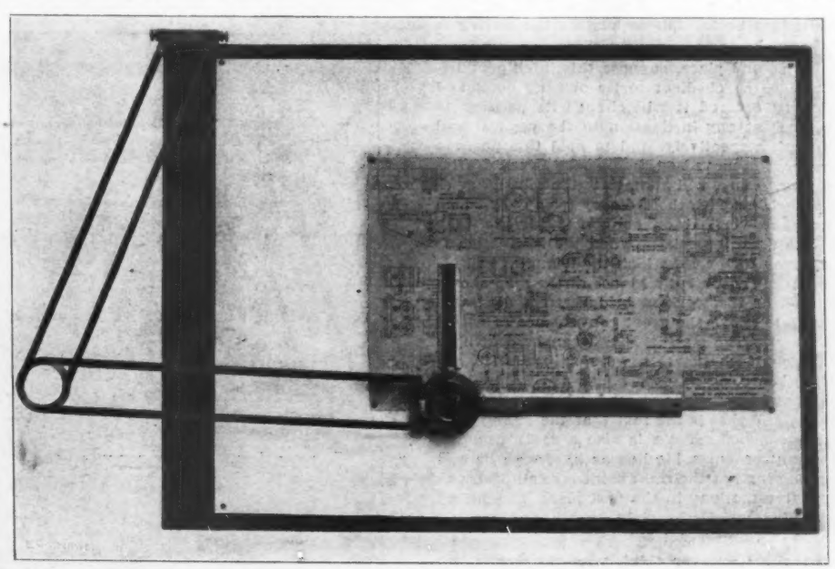


FIG. 2. UNIVERSAL DRAFTING MACHINE AS USED FOR DETAIL MACHINE DRAWING.

To give the best idea of what the machine does for the draftsman, let us suppose that an ordinary

right triangle were so endowed with intelligence that no matter where it were moved on the board under the draftsman's hand, its vertical side would stay vertical and its horizontal side would stay horizontal, with no attention on the part of the draftsman. Would not such a triangle be a great aid to the draftsman, enabling him to work more rapidly than he now can when his pencil hand must put in a good share of its time adjusting T-square, triangles, scales, etc.? But the system of four links, seen in Fig. 1, connected to these two straight edges, held at right angles to each other, is the equivalent of just that intelligent triangle which we have imagined. Move the instrument where you will on the board and its vertical edges remain vertical, and its horizontal edges horizontal, so long as the setting is not changed.

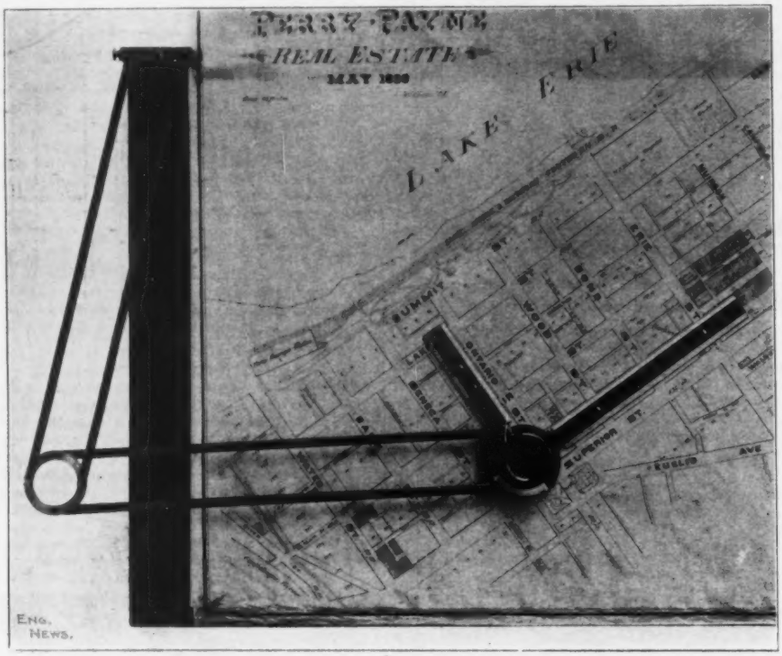


FIG. 3. UNIVERSAL DRAFTING MACHINE AS USED FOR MAP WORK.

In the second place, suppose this intelligent triangle to be so obedient to its owner's command that when ordered it will change its position to draw lines at any inclination to the vertical and horizontal, respectively, and to hold this position wherever it is moved on the board. Every draftsman, we are sure, will appreciate the advantage of such a tool, for with the ordinary tools lines which are neither vertical or horizontal always take longer to draw, especially when the inclination is not an even 30° or 45° which the triangles will directly fit. It needs but a glance at the map shown in Fig. 3, or the work in bridge stress diagrams in Fig. 4 to prove the great convenience of a tool of this sort. The map in Fig. 3 can be drawn as rapidly as if the streets were square with the drawing board.

And now comes in a second advantage of the machine, and that is the fact that the ruling edge which the pencil follows is also a scale, and the draftsman measures his line as he draws it, and stops his pencil at the right point instead of drawing the line too long in the first place, picking up a scale, laying off the right length and erasing the part of the line not required.

Did the reader ever think why the draftsman pursues this roundabout method, and why scales are not placed on the edges of triangles? It is simply because it would take too long to adjust triangle and T-square so that the zero point on the former would coincide with the point where the line is to begin. With this machine, however, the old difficulty entirely disappears. The draftsman simply moves the zero of the ruling edge to the point where he wishes a line to begin and draws the line the right length at once. He is relieved of all care as to the angular position of his lines when once he has set the instrument to the desired position. It may be said here that while the protractor attached enables the instrument to be set to any angle, spring stops are provided at 16⅔°, 30°, 45° and 60°, enabling instant adjustment to these frequently used angles.

Turning to the mechanical construction, as may be supposed, the blades of the square are interchangeable, and a plain straight edge can be substituted for inking or for very long lines. Any length desired or any graduation can be supplied.

The parallel motion is obtained by means of two pivoted parallelograms, which constitute an arm joining the square to the board. This arm is made flexible, allowing the blades to lie flat upon the drawing. It is hinged at the connection to the board and may be easily lifted out of the way of the paper. It may be readily changed from one board to another. The square moves about the board as easily as though it were not joined to the arm.

It will naturally be inquired whether wear at the joints of the link-work will not soon produce lost motion and inaccuracy in the work. In reply to this it may be said that the ring is of phosphor bronze, the arms of the link-work are of steel and the joints are made with steel pins working in the phosphor bronze, on which, with very slight motion and low pressure, the wear should be trifling. A conical adjustment to take up any lost motion is provided, however.

The practical advantage of the machine may be summed up in the statement that it saves from 30% to 50% of the time required to produce finished drawing by the ordinary T-square and triangle method. It does this by relieving the draftsman of a large part of the drudgery of his work—the constant adjustment of the tools to guide his pencil—and enables him to concentrate his mind on the portions of his work which call for skill and judgment.

The machine is the invention of Mr. Chas. H. Little, of Cleveland, O., an engineer formerly connected with the Wellman-Seaver-Morgan Engineering Co. It is being manufactured and sold by the Universal Drafting Machine Co., of Blackstone Building, Cleveland. Although its introduction has only just begun, it has met with a very favorable reception in every drafting room where it has been tested, and a considerable number are now in use in the principal drawing rooms in Cleveland and Pittsburg and vicinity. Among recent orders is one for 50 machines for the Westinghouse Electric Co.

INTERLOCKING CONSTRUCTION AND SPECIFICATIONS.*

By C. O. Tilton.†

While the subjects of interlocking construction and specifications have been discussed informally before the club, they have never been made the subject of a special article, and although it would seem as if these points should be pretty thoroughly understood by this time, the fact that so many inquiries reach the different roads for their specifications would seem to be cause enough for a short article on the subject.

A general plan should never be drawn up without first going over the ground so that the interlocking station may be located where the best view will be obtained and the best results secured in regard to the lead out and running of pipe lines. Street or road crossings should always be located so that heavy boxing may be provided. Provision should be made for any possible chance of an additional track being laid in the future and the interlocking station located so as to allow for it. The expression interlocking station has been used here so as to conform to the latest ruling of the American Railway Association, as it would seem advisable that we adopt the terms recommended by the association, practically all the railways represented in the club being members of that body.

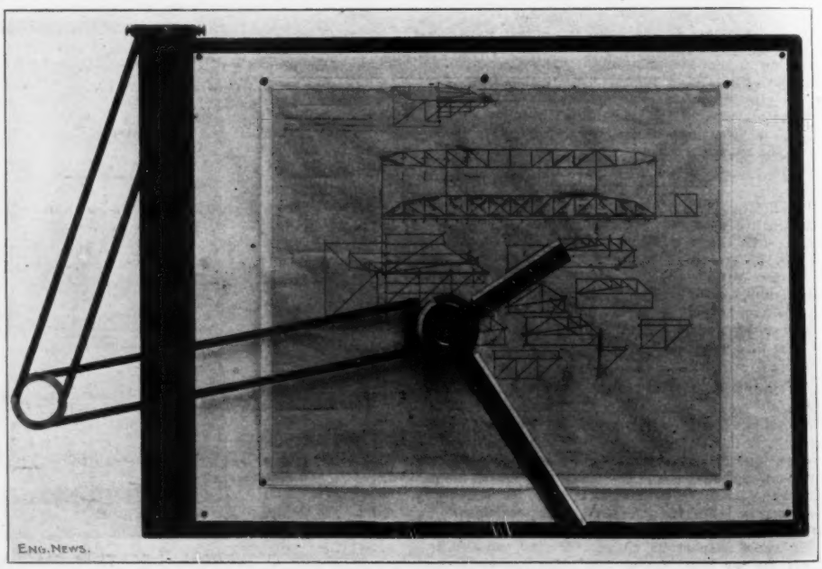


FIG. 4. UNIVERSAL DRAFTING MACHINE AS USED FOR STRESS DIAGRAMS IN BRIDGE WORK.

*Abstract of paper read at the May meeting of the Railway Signaling Club, in Chicago, May 13.

†Signal Inspector: Chicago, Milwaukee & St. Paul Ry., West Milwaukee, Wis.

numbering up a plan, the levers should be grouped ach road, as this saves walking on the part of the iman and simplifies and expedites the operation of lant. This is not such an important item in small locking but is a matter of worthy of consideration large machines. In locating derails it would seem able to put them at least 500 ft. from the fouling on all high-speed main lines and deflect them to- the greatest angle, pipe lines being run on the site side of track from derails wherever possible, as experience has shown that a derailed train can do con- rable damage to a pipe line if it leaves the track. To rome this and to keep a derailed train on the track well to use a short guard rail.

Concrete foundations are to be preferred to wood, are as expensive as iron, and can easily be made on the ound. Signal poles, crank and compensator tops should of iron, or the cranks and compensators may be set on on anchor posts embedded in concrete. This substitu- on of iron for wood is in the line of permanent construc- on, as experience in the past has shown that interlock- ng plants with wooden poles and foundations have to be ractically rebuilt every six years. Another point worth mentioning is leaving boxing off of pipe lines. This engthens the life of the pipe as it does rust as uickly, and it is certainly more accessible.

Levers should not be overloaded, and a derail at 500 ft. worked with a switch and lock movement is sufficient load for one lever. Experience with old plants has shown the necessity of this, as it was customary to work a cross- over or two derails each at 300 ft. from the crossing, or other combinations too numerous to mention, on one lever, and expect some lightweight operator to handle them without continually kicking about hard-working levers, not to mention the continual wear and tear on the pipe lines and connections on account of additioal friction. It is therefore to our advantage to load levers lightly. Facing-point switches should be worked with facing-point locks and derails, and the switches bolt locked with their respective home signals whenever practicable. It would seem necessary to bolt-lock facing point locked switches, as the bolt lock is really the key to the situation; other- wise we have to depend entirely upon the plunger of lock entering hole in lock rod.

All derails, switches and home signals to be worked with pipe; on account of the double spectacle casting coming into general use. With green for the "clear" signal it is necessary to have the home signal more positive in its action, as it requires the lower opening in double spec- tacle to properly cover the lens of lamp so the green light may show up to advantage. With the single-light spec- tacle casting, all that was necessary was to have the arm come down to about 45°, and the white light was exposed. For these reasons, if for no other, it would seem advisable to connect home signals by pipe, as wire (on account of expansion and contraction due to changes in temperature) is unreliable. No selectors to be used, and mechanical distant signals and dwarf signals to be worked by two lines of wire.

Where it is necessary to have a two-arm home signal, it would seem good practice to put the lower arm for the diverging route on the same pole about 10 ft. from the top of rail, blinding the light in the normal position. The engineman in this case will always get a high signal for his main line high speed route and will not be running against a red light at night, while the possibility of a false indi- cation being given at night by a broken spectacle glass (with the white light for a clear signal) is lessened. Elec- tric locking is now looked upon as one of the essential features of an up-to-date interlocking plant.

In regard to distant signals, there is a great difference of opinion. According to the definition of the American Railway Association the "distant signal is a fixed signal used in connection with the home signal to regulate the approach thereto." Would it not be a good idea to locate the distant signal 3,000 ft. in advance to the home signal, to make it of practical use for high-speed running; in which distance a fast train can be got under control. In order to place the signal at this distance it should be of the automatic semaphore type, as a wire-connected me- chanical signal at this distance is not a good working signal and cannot compare with the automatic signal in reliability; in regard to fire cost, the automatic signal ready for service will come to about $300 complete for each signal, and the mechanical signal $150.

THE NEW ELECTRIC RAPID TRANSIT RAILWAY IN BERLIN, GERMANY.

In February of this year a new urban rapid transit railway in the city of Berlin, Germany, was opened to public traffic. The enterprise is the final outcome of a project advanced by Werner von Siemens in the early 80's, which project, how- ever, was materially different from any subse- quently entertained. In 1891 the Siemens & Halske Co. initiated proceedings looking toward the construction of an elevated line running east and west through the city, and in 1895 the matter had progressed to the point where actual construc- tion was begun. Important changes have been made in the general plans since then (for instance, portions of the line, which was originally planned all elevated, were changed to underground), but work advanced steadily until by the end of 1901 the line was completed and ready for operation. This rapid transit railway is in all its details a notable piece of engineering work. The following description has been abstracted from a volu-

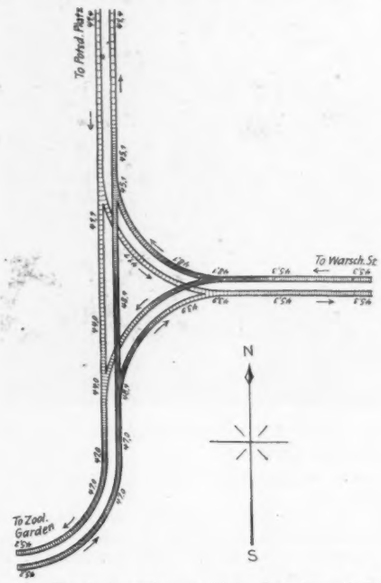


Fig. 1. Track Location at Y to Potsdam Railway Station. Berlin Electric Rapid Transit Railway.
(Figures denote elevations in meters.)

minous series of articles by Herr Langbein, one of the engineers engaged on the work, published in the "Zeitschrift des Vereins Deutscher Ingenieure" in February.

The line of the road crosses the city of Berlin in an east and west direction, and its length is about six miles. Its (present) western terminus is at the southwest corner of the Zoological Garden, in the Hardenberg-strasse. For about a mile eastward from this point the line is underground, and thence passing on to an elevated structure, it crosses the yards south of the Potsdam Railway Station. A short spur leaves the line here and runs to the latter depot, where it ends for the present. This spur sinks into subway in its terminal portion, and a projected extension northeastward from this point is also to be in subway. The main line connects with the spur by a Y-track over the railway yards; it then crosses the Landwehr canal and runs for some distance along its northern bank. Thence it goes directly eastward along Gitschiner-strasse and its prolongation, Skalitzer- strasse, crosses the river Spree, and terminates a short distance beyond, at the Warschauer-strasse Railway Station. This portion is all elevated.

For practically its full length the line passes along the center of public streets of exceptional width, and in some portions boulevarded. While this considerably simplified the problem of con- struction in many ways, it required much atten- tion to be paid to aesthetic features in the design of ironwork, bridges, stations, etc.

LINE CONSTRUCTION.

LOCATION AND CLEARANCES.—The line is built double-track throughout, and of standard gage. Curves have a minimum radius of 262.4 ft. (80 m.). The maximum gradient is 1 in 38, but where the main line rises from subway to elevated a grade of 1 in 32 was found neces- sary. The clearance diagram for the line is roughly rectangular, 10.8 ft. (3.3 m.) high above top of rail, 9.1 ft. (2.78 m.) wide; the center dis- tance of the two tracks is 9.8 ft. (3 m.) where the line is on embankment or elevated structure, 10.6 ft. (3.24 m.) where the line is in subway, the tracks being properly spread on curves. Stations were located from 1,500 ft. to 6,300 ft. apart, placed, where possible, on squares and street in- tersections having heavy traffic.

An unusual detail in the location was decided on for the Y-track where the spur to the Potsdam Railway Station branches off the main line. As no station was located at this point, it was con- sidered necessary, in order to avoid delays in traffic here, to arrange the tracks without grade crossings. The sketch, Fig. 1, shows how this was done, the shading of the tracks indicating the relative positions of the tracks. The compli- cated intertwining of the tracks presented quite a problem in design of the supporting structure; a masonry arched viaduct, with steel bridges at the wider crossings was constructed as best fitting the conditions. A view on the eastern part of this viaduct is shown in Fig. 21;* the tracks curving away to the right and left are plainly shown, and in the distance can be seen the line running north to the Potsdam Railway Station.

The clearance required over public streets was in general only 9.2 ft (2.8 m.), but over the cross- ings a clear height of 15 ft. was called for; where railway tracks are crossed, the clearance is 15.7 ft., but in two cases greater heights were required, up to 19.2 ft. (5.85 m.). These dimensions in general fixed the elevation and grades of the ele- vated portion of the line. Those in the subway were fixed by the requirement of the authorities that the highest point of the structure be at least 2.3 ft (70 cm.) below the surface of the pavement, or at stations at least 1.3 ft. (40 cm.). The maxi- mum difference in elevation on the whole line is nearly 65 ft.

ELEVATED STRUCTURE.—For the design and calculation of the structure the live load was given by the motor-cars to be used. These cars, with two 4-wheel trucks each, had axle-loads of 6.5 tons, the axles being spaced 5.9 ft., 15.0 ft., 5.9 ft., 11.2 ft., in sequence. Wind pressure was figured at 25 lbs. per sq. ft. in built-up districts, and 31 lbs. per sq. ft. in more open districts. The effect of centrifugal force was figured in the ordinary manner for a train-speed of 25 miles per hour. The inertia effect of braked trains was taken as 1-7 of the weight of the train.

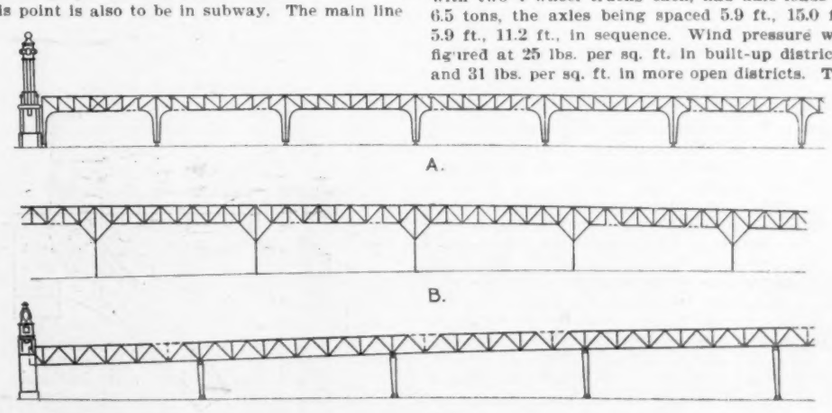


FIG. 2. TYPES OF STEELWORK OF ELEVATED LINE-STRUCTURE.

The permissible unit stresses for soft steel were from 13,500 to 18,500 lbs. per sq. in. for main truss members, both principal and secondary

*We are indebted for this view to Mr. Oscar Lowinson, Assoc. M. Am. Soc. C. E., of 39 Cortlandt St., New York

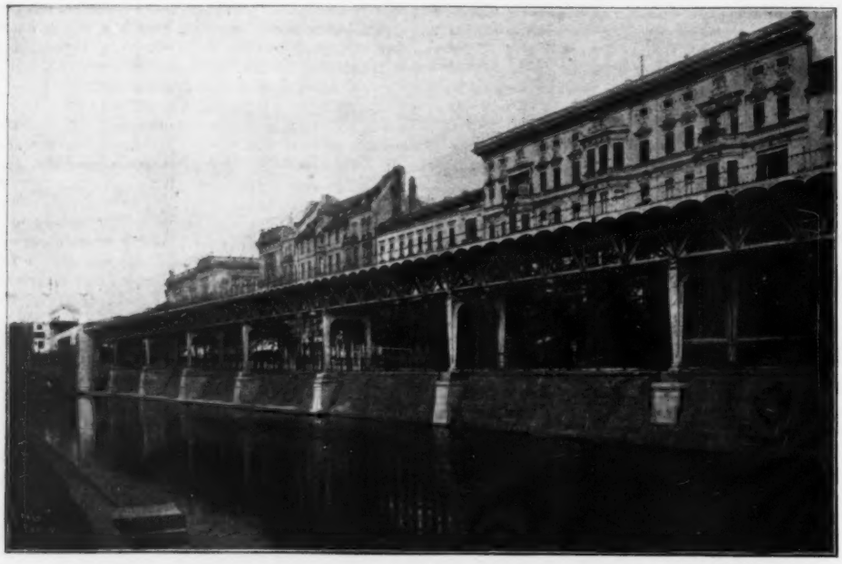


FIG. 3. ELEVATED STRUCTURE ALONG NORTH BANK OF THE LANDWEHR CANAL, STATION HALLESCHES THOR IN THE BACKGROUND.

stresses being considered; 10,750 lbs. per sq. in. for the floor system, and 20,000 lbs. for wind-bracing. The allowed stresses on other materials were, in lbs. per sq. in.: Cast steel, 14,250; masonry, 160 to 200; stone, 575 to 710; concrete, 85 to 140; wood (pine), 850. In the design of main truss members, reduced unit-stresses were used in cases of reversal of stress. Stiff members were in all cases given the preference over rods or bars.

The design of the elevated line-structure presents a number of different types, illustrated in Fig. 2. The aim was to decrease as much as possible the section of the posts at their base, so as to minimize the obstruction of the street. At A, Fig. 2, is shown the type of structure used for the greater part of the line; alternate bays form cantilever spans and suspended spans, and the trusses connect to the posts by heavy curved knees, which transmit longitudinal forces to the bases of the posts. The type shown at B was used at one point to secure increased strength and rigidity. Where the line runs along the Landwehr canal the structure is of the type shown at C, in which the longitudinal forces are not transmitted to the posts, but are carried to masonry abutment towers at street intersections. This portion is further illustrated in the view Fig. 3. In the regular type of structure, expansion joints are introduced in every second panel, at the connection of the suspended span to the cantilever span; in the longer bays a sliding bearing is used for this purpose, in the shorter bays a pendulum vertical, pin-connected at top and bottom was used.

The structure is all of the deck type, one truss being set under each track. The roadbed is carried on transverse floor-beams at the panel-points, of rolled section or plate-girder; no stringers are used in the floor system. Two methods of support of the roadbed are used. On the eastern half of the line the ties are bolted directly to the floor-beams (see Fig. 18), the rail spanning the distance between (4.9 ft., or 1.5 m.); trough-plates set "standing" close the spaces between the floor-beams, being covered with gravel-concrete to deaden the noise of trains. On the western portion of the line the ties rest in gravel filling placed on "hanging" trough-plates bolted to the floor-beams. The roadbed will be referred to farther on. The transverse bracing, determined by the method of floor construction, consists of kneed brace-frames between the posts. Fig. 4 shows at the right the general type of cross-frame used, while Fig. 5 shows a special form of bracing used over boulevards, where the posts are splayed to clear the footwalk below. With the type of structure shown at C, Fig. 2, the tops of the posts are connected by a box-girder strut, the whole framed together to form a rigid portal.

The main trusses are of different spans at different points. The panel-length of 4.9 ft. is uniform throughout; the spans used are multiples of this distance, 39.4 ft., 54.1 ft. and 68.9 ft. (12 m., 16.5 m. and 21 m. resp.), but under stations the span-length of 49.2 ft. (15 m.) was generally used. The distance apart of the trusses also varies, being from 11.5 ft. to 13 ft., or 20.5 ft. at stations. The general details of the steelwork are illustrated by Figs. 4 and 5.

At the street crossings and where the line traverses open squares a greater clear height above street level was required, as already mentioned. The trusses at these points were set above the roadbed; this was further desirable because the long spans necessary here made a departure from the general type of trusses appear of advantage. A view of such a street opening is shown in Fig. 6, which shows a pair of through truss set on stone abutments. Where larger open squares had to be crossed, an arrangement like that at C, Fig. 2, was used, with the trusses set above the roadbed. The general detailing of the through-truss work can be seen from the cross-section, Fig. 7. It will be remarked in Fig. 6 that the street crossing is flanked at either side by cut-stone piers surmounted by ornamental pylons. These are a general feature of the line, particularly in its western portion, and aside from their own aesthetic effect, they "break the monotony of the long stretches of viaduct."

The weights of steelwork required for different portions of the elevated structure are shown by the following table; the weights given include posts and floor-beams:

Weights of Steelwork of Elevated Structure in Pounds Per Running Foot.

Span bet. posts, ft.	Length of Suspended span, ft.	Depth of truss, ft.	Spacing of trusses, ft.	Clear height, ft.	Weight, per ft., lbs.
39.4	29.5	3.6	11.5 & 13.8	10.5	810
49.2*	29.5*	5.7*	19.7 to 20.5*	12.4 to 15.7*	1,145*
54.1	34.4	3.6	11.5 & 12.8	14.8	940
68.9	49.2	5.6	12.8	16.4	1,210

*At stations; weight includes platform brackets, but no framing for station.

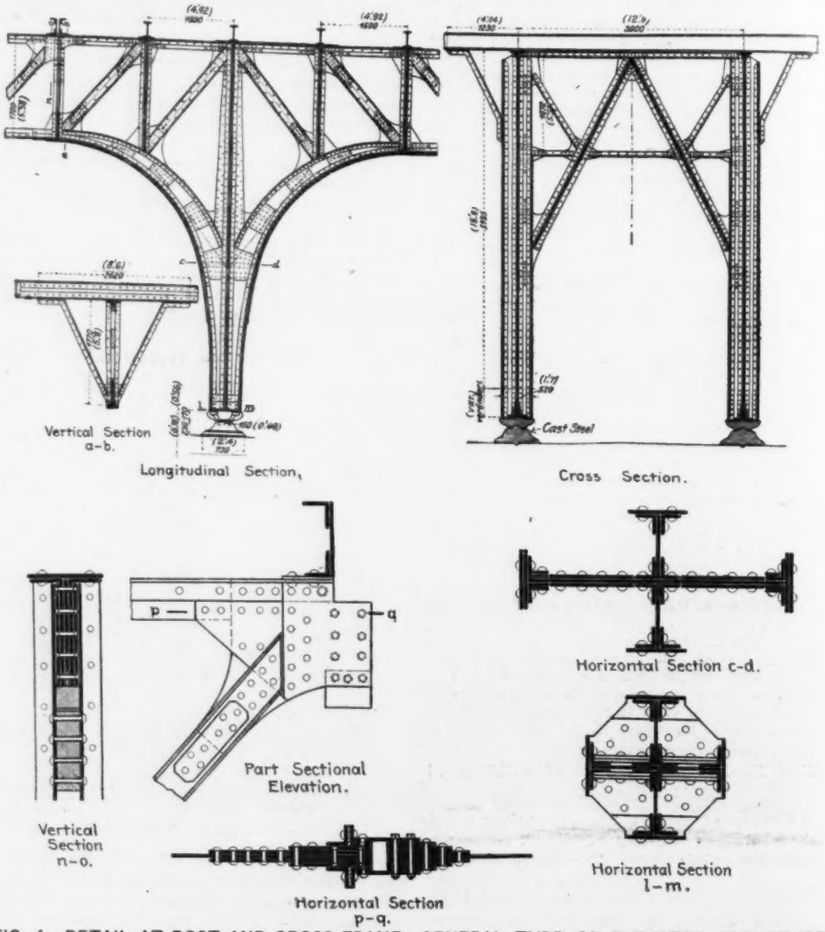


FIG. 4. DETAIL AT POST AND CROSS-FRAME; GENERAL TYPE OF ELEVATED STRUCTURE.

The erection of the elevated structure presented few unusual features. Good subsoil was met with at nearly all points, and the foundations could be kept above groundwater level. At some points, however, particularly in the vicinity of the Land-

...r canal, the foundation work was less simple. ...ng, lowering the groundwater level by pump- ...and concrete work below water became neces- ...y in different instances. Some complication ...ulted at two points from large trunk sewers

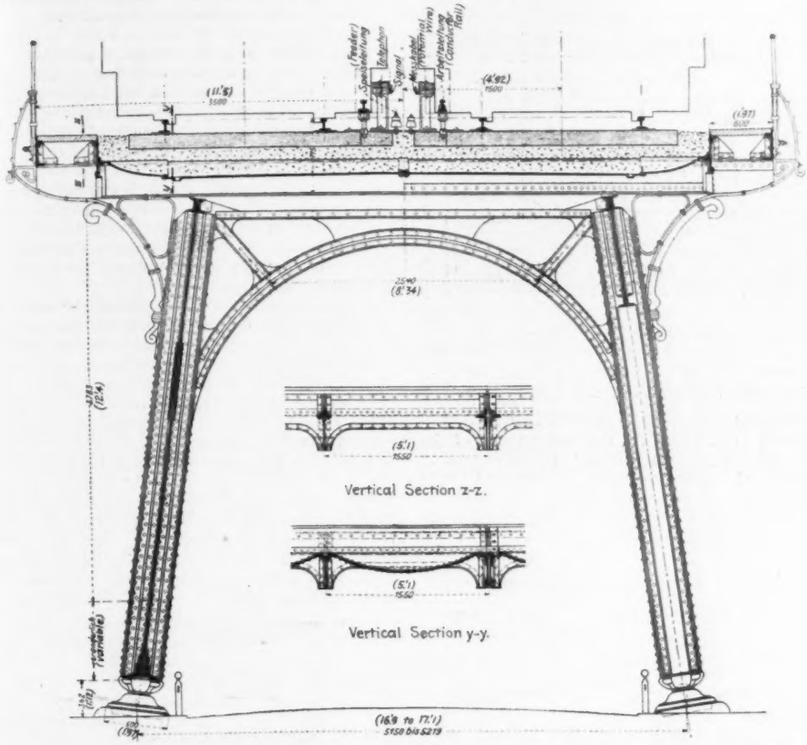


FIG. 5. CROSS-SECTION OF STRUCTURE OVER BOULEVARD IN THE BULOW-STRASSE.

which could not well be moved, so that it became necessary to build them into the foundation.

In the erection of the steelwork, at first a gantry traveler was employed, surrounding the permanent structure and running on tracks in the street at either side. Later it was found more simple to use portable platforms and horses, raising the pieces of the work by block and tackle. The erection of the bridge shown in Fig. 14 was a little more difficult. It was found necessary to erect falseworks, consisting of four temporary iron bridges mounted part on piling and part on pontoons. A traveler running on these temporary spans set in place the members of the permanent bridge.

SUBWAY STRUCTURE.—Clearances and loads have already been referred to. An additional consideration in designing the framework of the subway was the loading from the street above; besides the dead weight of the pavement, a maximum loading of a 20-ton steam roller, or trucks with wheel loads of 6 tons, was assumed. Only

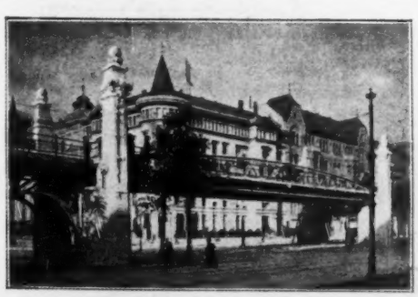


FIG. 6. CROSSING OF THE FROBEN-STRASSE.

about one mile of the line as at present built is in subway.

In Fig. 8 is shown a transverse and a longitudinal section of the subway structure. The floor and sidewalls are of concrete, forming a monolithic structure. The sheet piling of the trench used in construction is generally left in position, as shown. The waterproofing layer is 8 ins. from the outer surface on the bottom and within 4 ins. of the outside of the concrete in the sides and roof. The roof consists of concrete arches sprung between I-beams bearing at their ends on the concrete sidewalls and at their center on longitudinal 20-in. I-beams carried by central posts. The arrangement of this framework is shown in the figure. The posts are spaced 11.5 ft. and 14.8 ft. alternately (3.5 and 4.5 m.); the roof beams are spaced 3.3 ft. and 4.9 ft. (1.0 m. and 1.5 m.), the variation in spacing being evident from the cut. The longitudinal girders are placed only in alternate panels, and are cantilevered over to support the adjacent roof beams of the intermediate panels; this construction was found to result in economy of metal. The longitudinal section in Fig. 8 also shows how, at intervals, wire and pipe ducts were carried across the roof without encroaching upon the pavement. A trough plate connected to the beams and having the waterproofing and its concrete protection properly carried across, here takes the place of the regular concrete roof arch.

Refuge niches are built in the sidewalls at intervals of about 80 ft.; a footwalk runs along the center, between the columns. In the middle line of each track a drain is formed in the concrete of the floor, covered with plates of concrete; a sufficient protection of ballast is left between these plates and the ties of the track.

In Fig. 9 is reproduced an interesting comparison of cross-sections of the subways and tunnels of various underground urban railways—the London tubes, the Paris Metropolitan Railway tunnel, and the rapid transit subways in Glasgow, Budapest, Boston and Berlin.*

The construction of the subway portion offered many points of difficulty and complication, in spite of the short length of the subway. It was possible to construct the whole of the subway in open cut, but the unreliable soil and the large amounts of groundwater made it necessary to adopt unusual methods in many portions. The method of keeping the trench free from water by lowering the groundwater level by pumping was extensively used. The bottom of the trench was on the average 15 ft. below the normal level of groundwater. The trench was usually lined with sheet piling, arranged in two tiers in the first part of the work, but later in only a single tier. With two rows of piling, the pump wells were driven in the bench, about 30 ins. wide, between the two rows of sheeting. When but one row was used, the wells were driven just outside of the sheeting. Fig. 10 shows the arrangement of the trench, piling and wells, with the single and double tier methods of sheeting. The wells were set about 30 ft. apart, longitudinally, and about 40 such wells were connected to a common suction main and operated from a single pumping station. The construction of the wells will be clear from an inspection of Fig. 11. The outer tube is composed for the greater part of its length of perforated copper, surrounded by copper gauze, and an inner suction tube reaching nearly to the bottom of the well draws off the water flowing in through the perforations. At one point of the work the layers of sand and gravel, which carried large quantities of water, were interrupted by an impervious layer of clayey marl. In consequence of this it became necessary to sink some of the wells into the layers below the marl, while others tapped the overlying water-bearing strata.

In all this work is was found that within two or three days after beginning pumping the level of the groundwater was lowered sufficiently to carry on the excavation to the full depth of the trench. The material was removed by dump-cars running on a track partly in the trench and partly on the street surface.

Special methods had to be used where the spur to the Potsdam Railway Station is in subway. The trench here is directly bordered by foundation walls of adjacent buildings, in some cases on both sides of the trench. Extensive under-pinning was necessary, most of the foundations being carried down below the floor level of the subway. At this point, moreover, the subway is of extra width, and it was found preferable to excavate separate trenches for each sidewall, bracing the sheeting against the center core. The spoil-track was run along on the top of this core. After the sidewalls were finished the core was taken out in sections and the concrete floor laid.

Just beyond the terminal station of this spur the subway is extended a short distance in single track, for tail switching. Parallel with and immediately adjacent to the tail section is the location of a future subway planned by the city, and this future subway is from 10 to 15 ft. lower than the former. To avoid difficulties in the construction of the future subway, the foundations of the tail section were carried down by pneumatic work to a depth of 37 ft. below street level, sufficient to prevent any disturbance by the future excavation. This pneumatic foundation is quite short, and only two long caissons were required, being connected together and with the main subway by heavy concrete bridging sections.

The method of putting in the structure of the subway differed with the varying methods of excavation. Generally the floor and sidewalls were put in place together. The outer layer of concrete, mixed 1 of cement to 6 of sand and

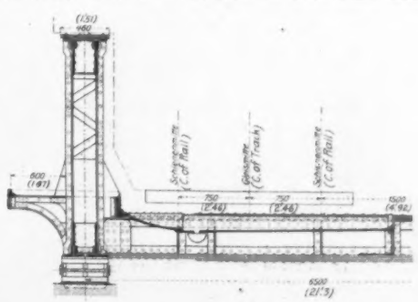


Fig. 7. Section of Truss and Roadbed at a Street Crossing.

gravel, was laid and its surface smoothed off; then the asphalt and felt was put in place in three layers, and finally the main body of the concrete was rammed in. Transverse templates were set at intervals, which gave the profile to

*A section of the subway of the New York Rapid Transit Ry. was shown in Engineering News of Feb. 20, 1902, p. 162.

the floor, with the drains in the tracks and the raised footwalk in the center, and which carried the molds for the sidewalls. The concrete for this part of the work consisted of 1 part of cement, ½ part of hydraulic lime and 7 parts of sand and gravel. It was mixed in machine mixers and carefully rammed in 8-in. layers. When floor and sidewalls were completed, the columns and roof beams were set and the concrete arches of the roof rammed in place on molds; the waterproofing in the roof had only two layers of asphalt and felt. The roof concrete was mixed 1 of cement, 8 of sand and gravel.

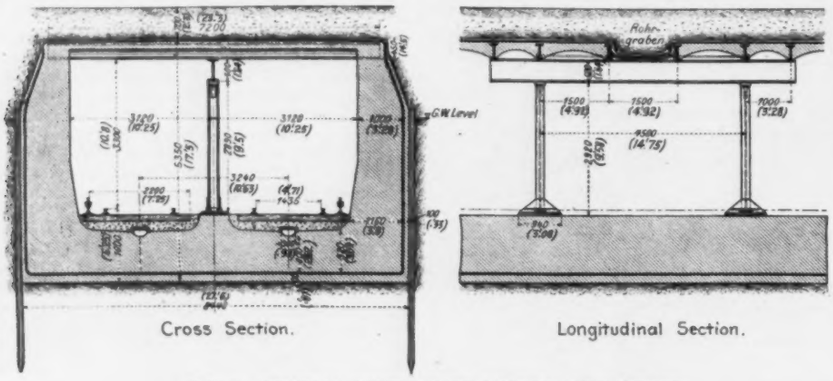


FIG. 8. GENERAL SECTIONS OF SUBWAY STRUCTURE.

At most points it was impossible to follow the above method of procedure exactly. Where the sheeting was braced, the upper part of the sidewalls could be placed only after the lower portion had set and the braces were removed. In the Potsdam terminal subway the sidewalls were executed in short sections, as piers of earth had to be left in place to prevent movements of the adjoining masonry of building foundations; the intermediate sections were placed after the first had set, and finally the central earth core was taken out and the floor laid.

A large amount of sewer diversion work was necessary in connection with the subway construction. In some cases sewers or water pipes were led under the subway by inverted siphons. In other cases intercepting sewers were built along the sidewalls and carried along on both sides to where the line emerges from subway; inverted siphons were added to this system at large cross sewers to carry off the large volumes of storm water more directly. Water and gas pipes were generally carried over the subway, though in some cases flattened wrought-iron pipes had to be used to make this possible.

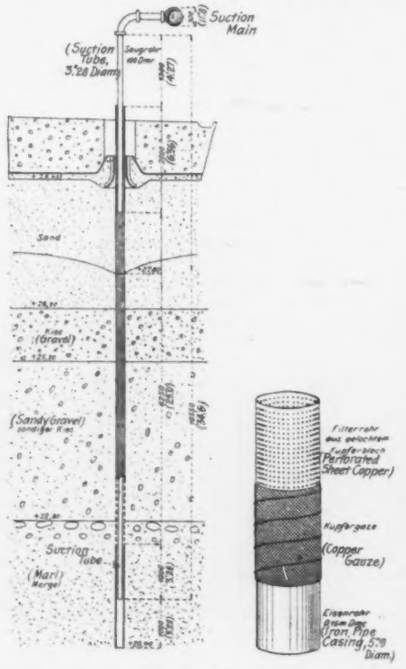
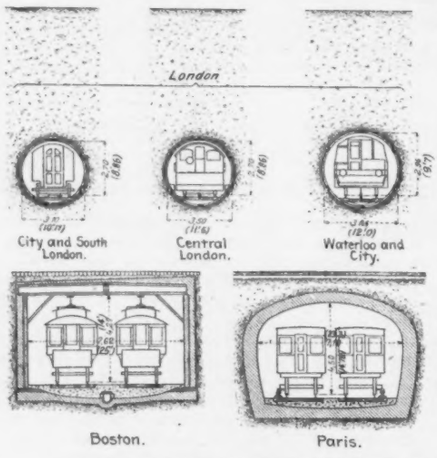


Fig. 11. Detail of Pump-Well.

STATIONS AND SPECIAL STRUCTURES.—Of the ten stations on the elevated portion of the line a number presented special conditions as to location, etc., that considerably affected their design. Moreover, a large element of variation was the architectural treatment: the stations are in some cases quite simple structures; in other cases they are ornate and imposing buildings. Disregarding differences, the general type of station is that shown in Fig. 12, which gives a cross-section through the station at the Kottbuser Thor. The length of platform is about 260 ft. on the average, roofed over for about 150 ft. The roadbed in the center is of the same construction and dimensions as on the open line; the platforms are raised to about the level of the car-floor, on brackets projecting from the trusses. It will be noted that a wider spacing of posts is used, and a different arrangement of trusses than on the open line. The truss spans at stations never exceed 50 ft., on account of the greater loading. The platforms, 10 to 11.5 ft. wide, are floored with steel-concrete plates of Monier construction, covered with 1 in. of asphalt. The roof is of corrugated steel on purlins carried by light arch frames; the walls are largely glass. The stairs are generally at one end, in the line of the platforms; they are of steel framing, with treads of steel-concrete surfaced with asphalt and having a nosing strip of ash. Where possible the stairs from the two platforms are brought together at the middle to a common stairway on their lower half; the ticket-booths are placed at the junction landing.



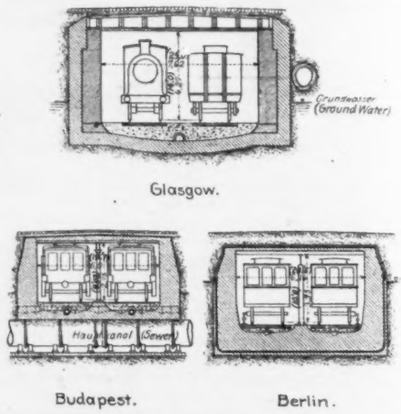


FIG. 9. COMPARATIVE SECTIONS OF UNDERGROUND URBAN RAILWAYS.

There are only three stations in subway as the line is constructed at present. The general type is shown in Fig. 13, which is a cross-section of the station at the Wittenberg Platz; the construction is similar to that of the subway proper, slightly different arrangement of roof-bearing longitudinals. The platforms at the sides track are at car-floor level; concrete re walls beside the track hold an earth fillin a pavement of asphalt. The stairways ar ends in the prolongation of the platforms.

The largest piece of special work is th porting structure at the Y-track connection Potsdam station spur, which has already referred to. This is carried out mainly in but involves also a number of bridges, s and minor portions of steelwork. Where th crosses the river Spree an existing stone bridge was utilized. This bridge was built b city only a few years ago, and was planned the first with a view to subsequently accom dating the elevated railway. The latter is ca over the bridge on a stone arch viaduct con ling of two lines of piers connected by a seri groined arches.

At the crossing over the Landwehr canal existing bridge of the Anhalt Railway spa the river about at right angles to the propo structure, but at a comparatively low level, that the elevated railway could cross above g with only slight extra elevation. A long rive truss through bridge was built here, as shown in Fig. 14, resting at one end on a stone abutment, at the other on steel posts. The illustration also shows the decorative touches that were added to the bridge; extra aesthetic effect was thought desirable on account of the elevated location of the bridge, which makes it a conspicuous object in the landscape. The portal at each end was ornamented by a false roof over the portal strut, flanked by small peaked towers over the hip-verticals; attached to the portal brace-frames are the coats-of-arms of the three boroughs through which the line passes, enameled in colors on steel plates. Decorative panels of similar enameled steel work are arranged at the tops of the vertical members of the trusses and a very elaborate railing is carried along either side of the roadway.

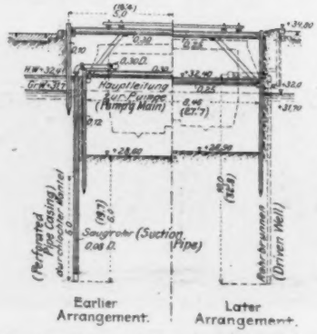


Fig. 10. Method of Excavating Subway.

ARCHITECTURAL FEATURES OF THE WORK.—Reference has already been made to the considerations that called for more than usual regard to aesthetic questions. The special efforts made to allow for them will warrant a brief refer-

due to the results. On account of the short time available for this part of the work, the elaboration of the architectural design was divided among a number of the leading architects of Berlin. Due supervision, however, combined with proper assignment of the different sections of the work, insured a harmonious treatment of the whole.

The extent to which the general design of the structure allowed for the aesthetic element may be gathered from the illustrations Figs. 3, 4 and 7. Where steel portal frames occur at street crossings, special effect was sought for, and the designs resulting are exemplified by the two portals shown in Fig. 15. The stone abutment piers with their ornamental pylons, which occur at intervals, have already been mentioned. Fig. 6 shows such a pier. At these points, also, the ornamentation of the adjacent street crossing was given particular attention. In the view Fig. 16 this is illustrated by the bridge seen in the foreground; it may be remarked, however, that this structure is located in a high-class residence section of the city.

The principal field of work for the architects was,

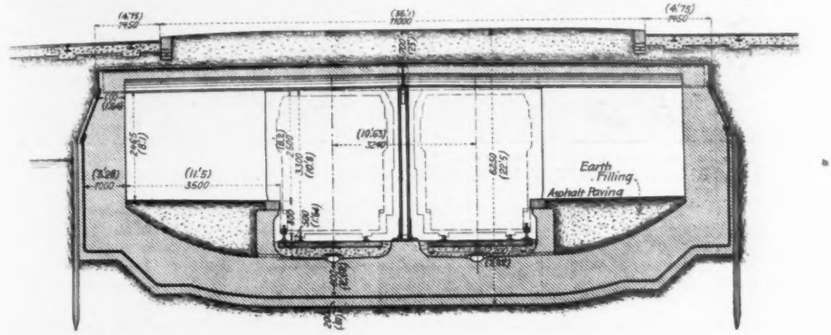


FIG. 13. STATION AT WITTENBERG PLATZ; GENERAL TYPE OF STATION IN SUBWAY.

naturally, the design of the stations, especially where the character of the neighborhood called for monumental effect. The Bülow-strasse station, one of the most richly treated, is illustrated in Fig. 16. Structurally, it differs from the type station in being carried on arched portals of pairs of stone piers under each platform, instead of on steel posts. These piers are carried up in the line of the walls and surmounted by short terminal shafts of stone. The manner in which the adjacent portions of the line structure, street crossing, abutment, piers, etc., are developed in harmony with the treatment of the station itself will be seen from the illustration. Another very elaborate structure is the station at the Nollendorf-platz, Fig. 17. This is the most westerly station on the elevated portion of the line, and for this reason it was thought proper to specially emphasize it. The large dome surmounting the station-building is the central feature of the design for this purpose. The method of support on stone piers, as in the last-mentioned example, and the other features of the architectural design, will be noted in the cut.

The subway portion of the line offered little opportunity for aesthetic treatment, even the stations being quite simple in character. Where the line runs into the subway from the elevated structure some care was expended on producing a pleasing effect: The roadway is enclosed between cut-stone masonry retaining walls, and the portal of the subway is properly emphasized and surmounted by an elaborate balustrade.

ROADBED AND TRACKWORK.—The construction of the roadbed has already been referred to. On the eastern section of the line there is no roadbed proper; the crossties are bolted directly to the top flange of the floor-beams and the rail spans the distance between; to protect the street below, and to deaden the noise of traffic, a concrete filling covers this space, supported on light steel trough-plates, set "standing," sprung between the lower flanges of the floor-beams. This concrete filling, since it carries no load, is made from a light volcanic gravel found in the Rhine valley, mixed with hydraulic lime and a small admixture of cement. The filling is carried up level with the tops of the floor-beams and covered with a layer of bitumen and jute; the top finish is a protecting layer of washed gravel. Holes are provided in the trough-plates at the proper point, for drainage, and longitudinal gutters below take care of all seepage.

On the western portion of the line, where it runs through a wealthy residence district, a roadbed of better sound-deadening construction was desired. The ties are therefore bedded directly in gravel ballast carried on "hanging" trough or buckle-plates of proper thickness to carry the load. The buckle plates connect to the top flanges of the floor-beams; the ties are spaced 30 ins. c. to c. A rail of ordinary depth could thus be used here, while the other construction required a rail of special depth; this will be referred to below, in the description of the rail.

Fig. 5 shows the roadbed construction last described, with ties bedded in the ballast; the other type of construction is illustrated in Fig. 18, the filling over the trough-plates not being indicated in the figure. The total width of roadbed is about 23 ft (7 m.) between handrails, which leaves ample space at either side of the track for a footwalk. The illustrations also show the arrangement of conductor-rails, feeders, signal wires, etc., in the center between the two lines of track. A variation in the roadbed construction occurs on the masonry bridge crossing the Spree. Here no ties are used, but the rail rests on a wooden stringer, which is held in a longitudinal steel channel laid flat, and further secured and stiffened by upright channels at either side of the stringer.

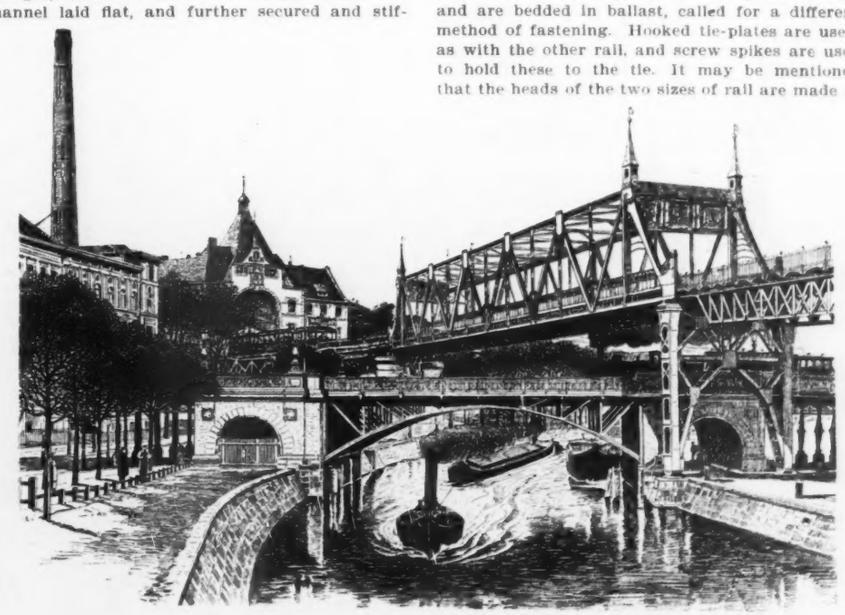


FIG. 14. BRIDGE OVER THE LANDWEHR CANAL.

One of the main governing features in the selection of the track details was smooth riding of the cars. It was thought that this would be best served by using a halved or lapped joint, and with this in view a special type of rail was adopted. The rail has its web shifted to one side of the center by half the web thickness; successive lengths of rail being laid with the web on opposite

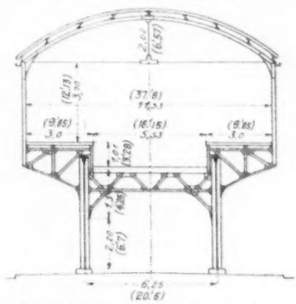


Fig. 12. Cross-Section Through Station at Kottbuser Thor; General Type of Station on Elevated Structure.

sides of the center, a halved joint will permit the webs to lap past each other in full strength, while head and rail-flange are halved. This is illustrated in Fig. 19. The lap of the webs is shown to be sufficient to take two of the splice-bolts, while angle-bars outside of the webs give a total of six bolts to the splice. The splice-bars bear against equal tapers under both sides of head and flange. All joints in the track are suspended joints.

The two different sections of rail used on the line are shown at a and b, Fig. 19. The section shown at a is 180 mm. or about 7 ins. deep, and weighs about 86 lbs. per yd.; the section b is only 115 mm. or about 4½ ins. high, and weighs about 51 lbs. per yd. The deeper rail is used on the eastern portion of the line, where the ties are spaced 5 ft. apart. The method of fastening this rail to the ties can be understood from views c and d, Fig. 19. A hooked tie-plate under the rail holds the latter with two rail-clips and four bolts, as shown; the bolts pass through the tie and through a steel bearing-plate between tie and floor-beam, riveted to the latter. The bolts are fitted with nut-locks at their upper ends; the holes shown in the web of the rail just outside the splice-plates are drilled for rail-bonds. The lighter rail, used where ties are spaced 30 ins. and are bedded in ballast, called for a different method of fastening. Hooked tie-plates are used, as with the other rail, and screw spikes are used to hold these to the tie. It may be mentioned that the heads of the two sizes of rail are made of the same width, to maintain the gage and simplify details at connections.

The trackwork in the subway sections is quite similar to that described above, the smaller size of rail, 51 lbs. per yd., being used. The chief

point of difference is the position of the conductor-rail, which is here carried along the outside of the track. Moreover, it is located relatively 2 ins. higher than on the elevated section, so that the car-lighting could be arranged to start automatically as the train strikes the subway section.

The conductor or third-rail is a steel T-rail of 5.5 sq. ins. cross-section, laid in lengths of about 40 ft (12 m.). The rail is spliced at the joints in the ordinary manner, and in addition is electrically bonded. (The track-rails, which form the return, are also bonded and cross-bonded at the joints.) The third-rail is supported on vulcanite insulators spaced 20 ft. apart. On the elevated portion of the line a longitudinal wooden protection stringer is mounted about 5 ins. above the third-rail and just beside it, supported on cast-iron saddles. This arrangement can be seen in Figs. 5 and 18; in the latter illustration longitudinal supporting pieces are shown which carry the third-rails, protection stringers and wiring, these being used because with the track-construction shown the ties are not convenient for the purpose. In the subway no protection-stringers were considered necessary except immediately in front of the refuge niches.

It may be mentioned here that the feeder shown in the sections of the elevated structure is a flat copper bar of from 1.5 to 2.3 sq. ins. cross-section, mounted on separate insulators.

In the car sheds and repair shops it was thought preferable to arrange the conductor-rails above the track, out of reach. They are here placed 13 ft. above top of rail, to one side of the

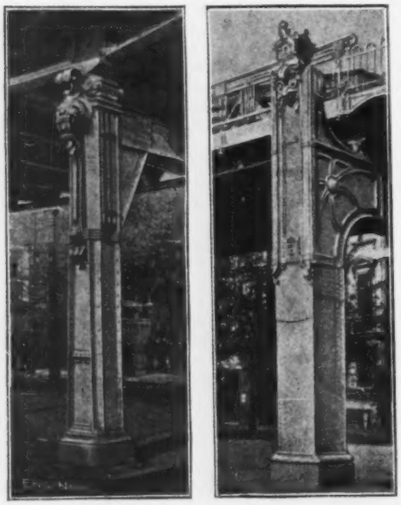


Fig. 15. Special Ornamental Columns and Portal Bracing of Elevated Structure.

track; the conductor consists of steel angle-bar, protected against accidental contact by a channel-shaped frame of wood.

POWER SUPPLY AND OPERATION.

SYSTEM OF SUPPLY.—On account of the comparative shortness of the railway line, and the feasibility of locating the central station near the middle point of the present system (which will also be near the center of the system as it is planned to extend it), a direct distribution from the power house was decided on. Accordingly, the generators deliver direct current at 750 volts initial pressure to the conductor-rails and feeders. The same source supplies the current for lighting the stations, car sheds and shops, but a separate circuit is arranged for these. This lighting system is calculated to give a pressure of 660 volts at the most distant station, with either 12 arc lamps of 55 volts each, or 3 incandescent lamps of 220 volts each, in series.

POWER HOUSE.—The location of the power house is just east of the Y-track leading to the Potsdam Railway Station, at the crossing of the line over the Landwehr canal. The supply of water for condensing purposes can thus be taken directly from the canal. Fig. 20 shows a transverse section through the power house. The main building is about 73 ft. wide and 132 ft. long, out to out of walls. The chimney is located in the courtyard outside of the building.

The arrangement of the station is clearly shown by the illustration. On the ground floor

FIG. 16. BULOW-STRASSE STATION AND CROSSING OVER THE POTSDAMER-STRASSE.

are located the engines and dynamos, switchboards, etc.; condensers, feed-pumps and other auxiliaries occupy the basement. The boilers are placed on the second floor, along the sides of the building, the firing ends facing the center. In the roof-space above is formed a coal-bunker, with down-spouts which discharge the coal upon a pile in the center of the firing-aisle. The chimney is built as a flue only above the boiler-room floor. Below this level the shaft is utilized for storage on the lower floor, and for wash-rooms and locker-rooms above. The engine-room floor is divided by a longitudinal wall into two rooms, the engine-room proper taking up the greater part of the width. The smaller space contains in its lower portion the switchboard gallery, and on a mezzanine floor a repair shop and other rooms. The engine-room proper is divided by a line of columns into two longitudinal bays; the one is at a higher level, and is the engine-floor; the other, at the lower level, is the dynamo-floor.

The engines, three in number, are vertical compound engines, with cylinders of 29.5 ins. stroke and diameters of 31.5 ins. and 50 ins. They are designed for a steam-pressure of 150 lbs., and a speed of 115 r. p. m., developing normally 900 HP., or as a maximum 1,200 HP. each. The total capacity of the station is thus about 3,000 HP. normal as at present installed. The flywheel of each engine weighs about 36 tons; the spaces between the arms are covered with sheet-iron, to minimize the air-resistance. For starting the engines a 20-HP. electric motor is provided, with connections to all three of the engines. The governor, set in the axis of the crank-shaft, is driven from a small crank on the end of the latter; from this crank, also, are driven the air pumps located in the basement.

The generators are Siemens & Halske shunt-wound dynamos, of a normal capacity at [illegible] volts pressure of 800 K-W. each. They are set entirely above floor-level, so that all parts are readily accessible. The main switchboard, located in a separate room on the engine-room floor, is fitted with the necessary switches, fuses, circuit-breakers and measuring instruments. A separate switchboard is used for the connections of the main and auxiliary storage batteries, and the booster-dynamo of the batteries; the booster is located immediately adjacent to this switchboard, and gives a pressure between brushes of 20 volts.

The main storage battery is of sufficient capacity to take the load of one generating set for one hour, but has a much greater capacity for shorter periods. A small 20-volt battery is provided for local lighting, being supplied directly from the booster-dynamo. Both storage batteries are located in the space under three adjacent spans of the elevated viaduct of the line.

Six boilers are provided; they are water-tube boilers with double drums, and may be worked up to a gage-pressure of 165 lbs. They have each a heating surface of 2,500 sq. ft, and in addition have one row of superheater tubes taking the place of the fifth row of tubes from the bottom. Connections are provided whereby the superheater tubes may be used as water tubes, when special demand is made on the boilers. In normal working the steam is superheated to 440° F.

Immediately below the firing aisle, and above the engine-room ceiling, is an ash-tunnel, into which the ashes are discharged directly from the ash-pits of the furnaces. On the same level, under the boilers, a smoke-flue is formed in the brick-

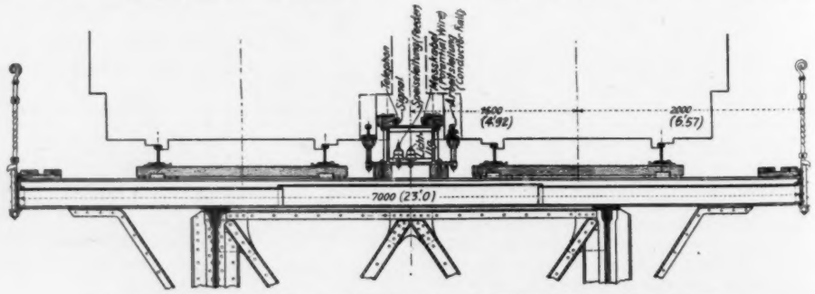


FIG. 18. ROADBED CONSTRUCTION ON EASTERN PORTION OF LINE.

work, which leads the gases to the chimney. The chimney itself is 260 ft. high above ground level but owing to the lower part being cut off as already noted, the height of the flue is only 215 ft.; its inner diameter at the top is 11.5 ft.

OLLING STOCK.—Trains are run on a headway of 2½ minutes to 5 minutes; the maximum speed is 30 miles per hour. Each train consists of three cars, two motor cars and one (middle) trailer. The motor cars are for third-class, the trailers for second-class passengers, and have respective seating capacities of 39 and 44, with room in each car for about 30 passengers standing. A car is 39.4 ft. long and 7.7 ft. wide. A door is provided at each end, one being for entrance, the other for exit. The seats are arranged along the sides of the car, separated into sets of three seats of 20 ins. width. Each motor car is fitted with three motors, but will have four when longer trains are used. Air-brakes are provided on each car; the reservoir is supplied by a pump driven by an electric motor mounted in the driver's compartment. Handbrakes are also provided, and the motors are designed for short-circuit braking for emergency use. Each car has a collector shoe on either side.

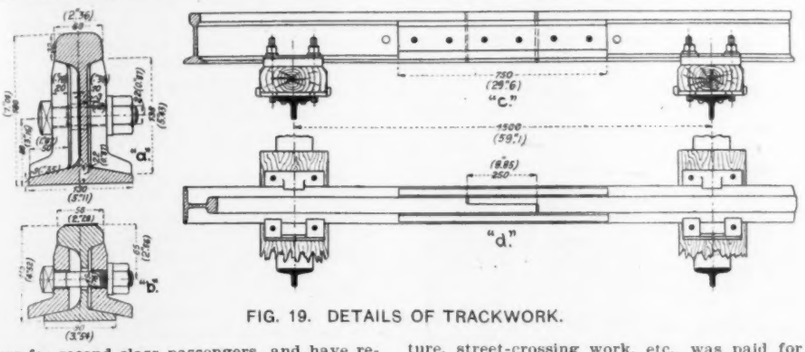


FIG. 19. DETAILS OF TRACKWORK.

SIGNAL SYSTEM.—As at present arranged, the blocks are identical with the distances between stations except at the Y-track leading off to the Potsdam Railway Station. Semaphores are used on the elevated part of the line, lamp signals in the subway. A single "departure" signal is fitted at each station except at the terminal stations and at the Bülow-strasse intermediate terminal, where both "arrival" and "departure" signals are placed. The semaphore at each station is operated by hand, and its setting to clear automatically notifies the preceding station that "block is clear" and the station ahead that "train is coming." Each semaphore arm is further electrically locked until the train at the next station ahead has passed at least a train-length out of the station. Thus a train does not start until the train ahead has left the next station, leaving the block entirely clear. Besides this automatic signal system, the different stations are connected by telephone. At the Y-track a more complete system of signals is arranged, and the signals are interlocked with the switches. The latter are operated and locked by a small electric motor at each switch. An operating tower controls the whole system at the Y.

COST OF THE WORK.

Though final cost figures are not yet available, those given below are closely approximate. The total cost of the road and equipment ready for operation, excluding cost of land, was $6,650,000 (this sum includes about $800,000 for extras not referred to in the preceding). Of this amount the cost of the line-work complete, excluding cost of land and the interest on capital, was $4,400,000, the cost of rolling-stock, power house and equipment, $950,000. The interest on capital invested exceeded $500,000.

Of the $4,400,000 for the line-work, the elevated portion cost $3,350,000, the subway portions cost $1,050,000. Reducing this to units of length, the costs per mile, including stations, etc., are $650,000 for the elevated work, and $860,000 for the subway work. Material prices naturally varied considerably, but average prices paid for work were as follows: Brick masonry above ground, laid in lime-cement mortar, $5.90 per cu. yd.; foundation masonry of hardburned brick in lime-cement mortar, $5.25 per cu. yd.; arch masonry, $7.85 per cu. yd.; concrete work in subway, including molds and settings, $4.60 per cu. yd. The prices paid for steelwork varied considerably, due to great fluctuations in the market, with a steady upward tendency of the prices of steel shapes. The total amount of steel used was about 18,000 tons for the elevated portion and 2,200 tons for the subway portions. The regular elevated structure, street-crossing work, etc., was paid for at the rate of $61 to $84 per ton, erected. The larger and more complicated parts of the work cost $76 to $97 per ton, erected. For the simplest steelwork, that in the subway, an average price of $42.50, erected, was paid.

SOME OBSERVATIONS UPON THE BINDING OF SAND BY STONE DUST.

By Halbert Powers Gillette.*

In "Economics of Road Construction" the writer attributed the binding or knitting of macadam to the influence of water used in puddling the screenings spread upon the broken stone; and expressed the opinion that the film of water around each particle of dust served to bind it to its neighbor by virtue of the well-known phenomenon of viscoscity or surface tension of water in capillary sheets.

Although this theory is probably true for macadam when newly made, since then it behaves much like the moist sand upon a sea beach, there ultimately comes a time when the water dries out, and although the macadam is then liable to ravel, it still possesses great solidity. The writer has, therefore, come to believe that while fine dust is essential to the binding of broken stone, that the water acts in another way also; and that by lubricating the dust particles or by forcing out the air bubbles or air film around each particle, the water enables the particles to come together, assisted by the pressure of the roller, until they are within the limits of adhesive attraction, whereupon they adhere much as do plates of smooth glass.

If the theory as outlined is correct, it follows logically that the size of the stone fragments is immaterial so long as the interstices are filled by progressively smaller fragments down to fine dust; and carried to its limit, the theory leads us to expect to find it possible to bind clean sand with fine stone dust, forming a Lilliputian macadam. That such a phenomenon occurs it is the purpose of the writer here to record.

Monroe County, N. Y., is justly celebrated for the number and excellence of its cinder bicycle paths. The soil upon which they are built is for the most part very sandy, not unlike that of New Jersey, and a coating of some kind is absolutely essential for bicycle riding. Some of the paths were built a number of years ago, and I have observed that in many places the cinders used in the original construction seem to have disappeared entirely, but nevertheless the path in such places remains hard and unyielding, and unless attention was called to the fact, the absence of cinders would not be noticed. Never-

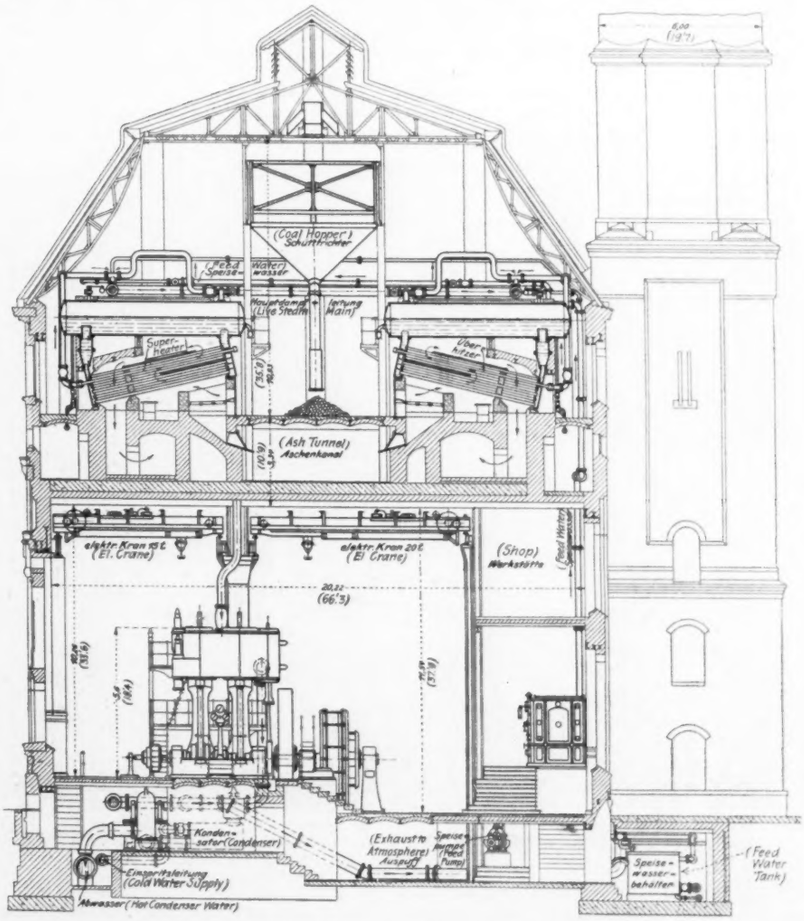


FIG. 20. TRANSVERSE SECTION THROUGH POWER HOUSE.

*791 Powers Block, Rochester, N. Y.

theless, there was a time when a bicycle could not have been ridden over these very places. What, then, has happened to convert the loose sand into a hard path? Unquestionably the cinders are accountable for the knitting together of the sand. Much of the cinders has been pulverized by the rolling of wheels and blown or washed away, but an examination of the sand shows that the rest of the cinder dust has been washed down into the sand voids, and there, by filling those voids, prevents displacement of the sand grains.

FIG. 17. STATION AT NOLLENDORF-PLATZ.

Not only in bicycle paths over sand, in roads made of shells upon sea beaches, in the hardening of quicksand that upon drying out often cakes into dense lumps, but in the crust of old, well-traveled earth roads do we find this same phenomenon of knitting, and recently I discovered a similar binding of the sand shoulders of a macadam road that I had built, and with every detail of construction and materials of which I am therefore familiar.

The macadam of this road is only 12 ft. wide through the most sandy stretch of the road, so that wheels of teams in passing frequently leave the macadam and come upon the sand shoulders. Engineers and residents alike feared for the life of the road in consequence of the probable crumbling or shearing-off of the macadam upon the passage of a wheel over its outer edge; and it was seriously argued whether or not a stone or wood curb along both sides of the macadam should be built. Indeed, another road only a few miles distant had been curbed with plank its full length, and was referred to as a good example.

When we found the sand so soft that a steam roller could not be used upon the shoulders, I must admit that my fears were likewise aroused, although they were somewhat quieted by the knowledge that even narrower macadam roads had been built in the sands of New Jersey without suffering subsequent destruction by shearing at the edges. One, however, is apt to think that the sand he is dealing with, be it "the quick or the dead," is somewhat worse than any other in the world; so I have waited and watched with many doubts as to the outcome. The road in question has now passed through its second summer with no signs of yielding at the sides, and instead of yielding, those same sand shoulders have become hard and compact! Wheels of heavy wagons travel upon them in many places without leaving a mark! What has bound this sand together? Obviously not rolling during construction, for it would not stand rolling, and received [illegible] nor could rolling of wagon wheels have bound [illegible] subsequently; for had they, there would [illegible] no need of macadamizing the road at all [illegible] had grown worse rather than better year after [illegible] year under wagon rolling. By exclusion we [illegible] left one factor only that can have caused the [illegible] knitting of these sand shoulders, namely, the [illegible] dust that the rains have washed off the [illegible] which dust has filled the sand voids and [illegible] the sand solid. A careful examination of the sand itself discloses the existence of the [illegible] dust.

We have now indisputable evidence of [illegible] accidental binding of sand in two ways, [illegible] by cinders on a bicycle path; second, by stone [illegible] on the shoulders of a macadam road. Why, then, should not engineers do artificially and [illegible] a purpose what has been done naturally or [illegible] accident?

It may not be feasible to make a road [illegible] to be traveled by horses and iron-tired [illegible] of sand knit with stone dust, but from the experience with bicycle paths it is clear that roads for rubber-tired automobiles may be so built, and the foundations of all classes of roads and pavements may be so made. The stone dust may be artificially pulverized sand itself, although limestone, where available, seems best. As to the best method of making such a sand road or foundation, it is evident that rolling, if done at all, must be toward the end of the process and with a light roller; and water must be depended upon to do the compacting by its puddling action, preferably delivered from a hose attached to the sprinkling cart driven alongside the road. In this way it is believed that substantial foundations for all classes of pavements may be made with sand alone, if screened, to secure the proper proportion of large fragments and dust, and to secure uniformity of the mixture; and it may be possible to so construct country roads for light traffic without other pavement.

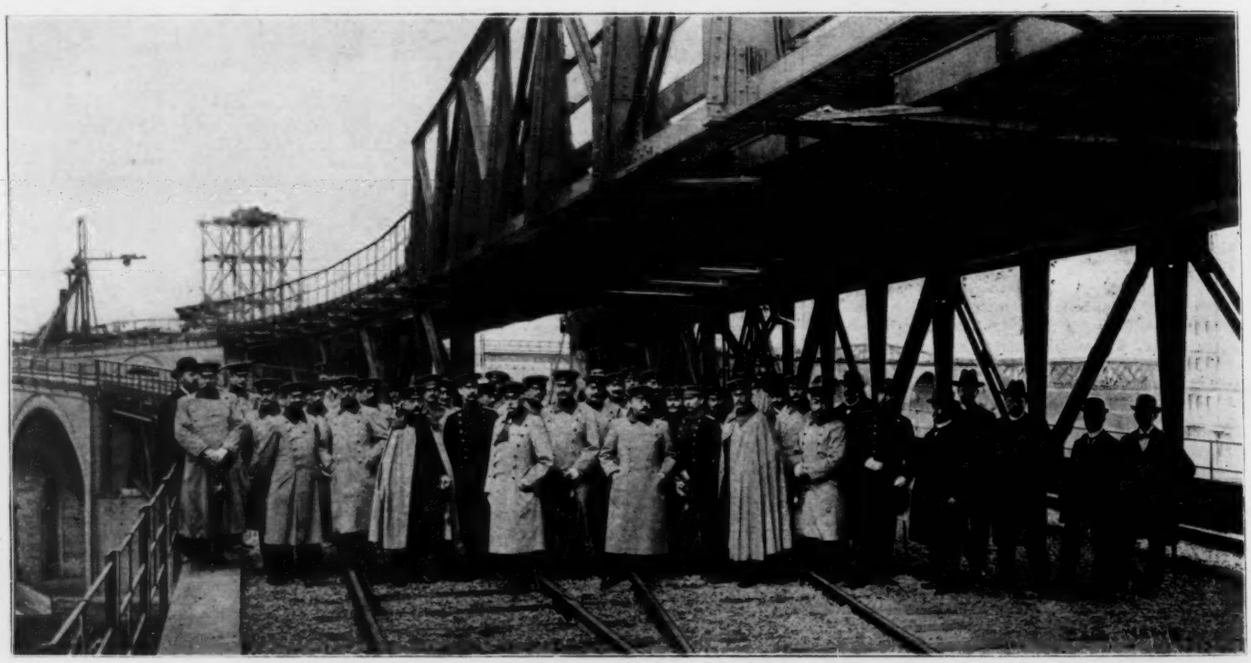


FIG. 21. VIEW ON EAST APPROACH TO Y-TRACK, SHOWING THE GENERAL STAFF OF THE GERMAN ARMY, AND ENGINEERING CORPS OF ELEVATED RAILWAY ON TOUR OF INSPECTION.

That neither rains nor wear of wagon wheels will readily destroy such a sand surface seems established by the fact above stated, that the sand shoulders of a macadam road are in excellent condition.

It is hoped that this record of the phenomenon of sand knitting will lead to observation and experiment along similar lines by other engineers engaged in road work.